THE EVOLUTION OF WATER PROPERTY REGIMES IN NORTH-CENTRAL GRAN CANARIA

By

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Bryan Thomas Byrne

To the Canary Islanders — May your winters be rainy.

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This dissertation explains the evolution of water property regimes in north-central Gran Canaria. Property regimes are sociocultural relationships governing the access, use, management and exchange of control over benefits accrued from resources, services, and ideas. Scholars usually identify state, common, and private property regimes. I identify property regimes by using a classification system developed by Edella Schlager and Elinor Ostrom to distinguish among private, common, and state organizations that may stand in relation to each other as owners, proprietors, claimants, and authorized users.

I argue that competing water property regimes evolved in response to changing international market opportunities and insular techno-environmental conditions that affected the relative costs and benefits of exploiting the island's water resources. The investments required to take advantage of market opportunities given the island's climate and water resources determine the demand for labor, and thus, the rate of population growth and settlement patterns. These, in turn, cause competition over water resources. Property rights associated with various property regimes tend to be distributed among social organizations in relation to their relative capacities to make and defend their capital investments and benefit in the exterior markets. When the external market and political forces change, new opportunities arise for adjustments to property regimes.

I demonstrate that the water property regimes on Gran Canaria evolved in response to external market forces and technological changes which transformed the island's mode of production from hydro-agriculture to industrial agriculture and, most recently, to urban based services that support tourism.

The model and the finding of this study suggest that similar evolutionary trajectories concerning property regimes should be found on other volcanic islands that are ecologically complex and almost completely dependent on international agricultural markets, tourism, and politically powerful trading powers.

CHAPTER 1

A GENERAL MODEL OF THE EVOLUTION OF WATER PROPERTY REGIMES ON GRAN CANARIA

This dissertation uses an ethnohistorical approach to clarify the principles governing the evolution of water property regimes in the north central region of Gran Canaria, one of the central islands in the Spanish Canary archipelago. Canary Islanders consider the effectiveness and legitimacy of water property regimes to be among the most important and divisive issues they have faced since the Spanish conquest in the 15th century. Despite their variety and complexity, broad evolutionary trends can be discerned and have become very important to current attempts to solve rapidly intensifying water management problems that carry with them a host of environmental, health, and economic threats.

It is possible to construct a general theoretical model capable of explaining the evolution of the property regimes in different epochs of the island's history. My model focuses on those ecological and sociocultural phenomena that have shaped and reshaped the insular sociocultural system since the Spanish Conquest. The general model relates external economic opportunities, local ecological features, technological options to exploit the island's resources, labor requirements, insular demography, exterior and interior political alliances, government administration, law, and property regimes.

My thesis is that the evolution of the island's water property regimes can be understood as a series of adaptations to external market opportunities and local techno-environmental conditions that have shifted the island's mode of production from hydro-agriculture to industrial agriculture, and most recently, to tourism and urban services. My theory starts with two propositions. First, people make capital investments if and when they have an opportunity to benefit materially and socially from them (see Acheson 1994) The second premise is that the Canary archipelago's economy has been primarily dependent on the vicissitudes of the European, North African, and American markets for agricultural products, transoceanic commercial shipping, and tourism since the Spanish conquest (see Galván Tudela 1988). Thus, Canary Islanders will make substantial capital investments in water resources when promising international commercial opportunities present themselves. The islanders must choose their investments carefully because the insular techno-environmental conditions determine the location, timing, volume, and kind of water available (Dirección General de Obras Hidráulicas 1980). Together, the external market and insular techno-environmental conditions influence which productive opportunities are most profitable, and thus determine the demand for water and related capital investments (CIES 1975). The production opportunities determine the demand for labor and, thus, influence population growth rates and settlement patterns (Martín Ruiz 1985). The demand for water, its location, the cost of technology, labor requirements, and settlement patterns create opportunities and constraints for individuals and groups with differential access to markets and capital to make and defend their investments for water resources (Rodríguez Brito 1995). These competing actors enter into and alter political alliances. They use legal and extra-legal means to gain proprietary control over water resources (Suárez Grimón 1988, 1990). I argue that the relative capacity of the competing groups to make and defend their investments causes changes in the distribution of water property rights and the relationships between them — often despite legal norms and decisions made by political authorities who seek to protect the status quo (Pospisil 1971).

My general model can be applied to describe and explain the development of water property regimes in the north central region of Gran Canaria over the past 500 years. The model predicts that when market opportunities and technological options change, so will patterns in capital investment, labor demands, population growth and settlement patterns. Accordingly, new opportunities for different groups to compete over specific water sources will arise and changes in water law and property regimes are likely to follow.

Property Regimes

Before proceeding, I wish to define property regimes and to discuss some of the theoretical issues they raise. Property is a universal characteristic of human sociocultural systems. Property may be defined as a set of sociolegal relationships which stipulate the rights, duties, liabilities, powers, privileges, and immunities that social actors hold with respect to each other and the benefits arising from 'things' such as resources, tools, people, and ideas (see Hohfeld 1919; Hoebel 1954; Pospisil 1971; Bromley 1991a,b). Property is central to debates about the evolution of political economies, resource management, and social justice because it amounts to culturally proscribed means of allocating the costs and benefits arising from productive and reproductive processes (Hallowell 1943, Hobel 1954; Bromley and Cernea 1989; Sanderson 1995).

Scholars studying the relationship between property regimes and resource management typically refer to an actor's ability to 1) gain physical access to the resource system and withdraw a portion of it; 2) manage it; 3) exclude others from gaining access to it; and 4) transfer any or all of these rights on either a temporary or permanent basis. By *access*, I mean the ability to enter a physical system such as woods, land, springs, aquifers, and irrigation networks. The *right of use* means the ability to manipulate and/or withdraw a portion of the resource. *Management* refers to the process of making decisions, directing laborers, and performing the tasks necessary to systematically manipulate the property itself. The *right of exclusion* simply means that the property holder may prevent others from gaining access and using the resource. Finally, the *right to transfer* means that the property holder may alienate one or all of these rights temporarily or permanently using well known techniques such as inheritance, sales, leases, concessions, verbal permission, specific-use contracts, etc.. Property holders may call upon superior political and military authorities (where they exist) to protect their claims, although there is no guarantee that they will succeed; property claims are only as strong as they are defended and/or enforced.

Although most scholars today restrict property to socially acknowledged and legitimated social relationships (Bromley 1991), emic norms concerning property rights may not coincide with etically observed behavior. Thus, it is entirely possible for the behavioral relationships among individuals associated with property to evolve at different directions and rates than normative judicial decisions and legal codes (Pospisil 1971).

A *property regime* is the combination of property rights and the institutional relationships among the social actors claiming them (Bromley 1989, 1990, 1992). The institutions themselves consist of rules and behavioral patterns among members and non-members with respect to the property. Bromley argues that it is normally sufficient to identify three property regimes and a special case in which none exist. *Res Nullis* (open-access) conditions are those in which no property rights exist. Independent individuals or groups may access and withdraw and manage the resources they capture without any duty to abide by anybody else's claim; nobody creates rules or behavior patterns that regulate each other's access or use of the resource. Some prime examples of res nullis conditions include the parts of the ocean, aquifers, mountainous lands, and space. *State, private, and common* property regimes are all named for the political characteristic of the actor claiming the title to benefits.

Cold War pressures on social researchers to avoid even the appearance of adopting research strategies most commonly identified with Marx and Engles handicapped research on property regimes because it lead them to focus almost exclusively on titleholders (see Harris 1968, Bromley 1990; Rudmin 1995). As anthropologists have warned repeatedly, the resolute focus on the institutional characteristics of title holders obscures theoretically important variations within property regimes and reduces theoretical discussions of property regimes to counterproductive debates about the relative efficacy of totalitarian communism and capitalist democracy (Hallowell 1943, Royal Anthropological Institute of Great Britain and Ireland 1951, Herskovitz 1952, Hoebel 1954). Unfortunately, the bulk of economists, political scientists, and anthropologists ignored the warnings and treated title holders as the loci at which all decisions are made about the control of resources (Bromley 1991b, Aguilera Klink 1994). The weight of ethnographic and historical research demonstrates that title holders are frequently not the primary decision makers or resource managers (McCay and Acheson 1987). Bromley (1989, 1991a,b) and Munzer (1994) suggest that managerial control, market dominance, market demand, and consumer-uses may be more theoretically relevant to issues revolving around the effectiveness, and thus, stability of resource management systems. Therefore, it is useful to distinguish among social actors who hold distinct rights to the same property and to describe their social relationships.

Schlager and Ostrom (1993) proposed an alternative way to classify bundles of property rights. Their classification system identifies the different kinds of property rights different actors may have within common property regimes. They identify four kinds of property based on an actor's right to:

1. Enter a resource area (as defined by its natural, technological, and administrative boarders) and to withdraw units of the resource itself for their own use.
2. Manage the resource system.
3. Exclude others from gaining access to it.
4. Transfer rights 1, 2, and 3.

Following this schema, *owners* possess all four rights (Table 1-1). Non-owners may still hold usufruct rights to property. *Proprietors* are social actors who do not own the property so they may not alienate the property, but they may use, manage, and exclude others from gaining access to it. *Claimants* hold usufruct rights that permit them to access, withdraw, and manage a resource but they cannot exclude others from gaining access or transfer their rights. *Authorized users* enjoy only the

Table 1-1: Property Types According to Schlager and Ostrom (1993)

Rights	Property Type			
	Owner	Proprietor	Claimant	Authorized User
Access and Withdraw	X	X	X	X
Manage	X	X	X	
Exclude	X	X		
Transfer	X			

right to access and withdraw resources. These rights may be subject to a variety of contractual and regulatory limitations and transferred via inheritance, sales, loans, concessions, leases, etc.

Note that Schlager and Ostrom's ordinal scheme says nothing about the social characteristics of the organizations holding the titles because they wish to distinguish among different kinds of common property regimes. Thus, it may also be applied to the state and private property regimes because it implies that private, common, and state organizations may stand in relation to each other as claimants, authorized users, proprietors, or owners. In a sense, their schema clarifies some of the usufruct property rights that are obscured by scholarly fixation on ownership and managerial control.

Still, their classification system is not sufficient because Schlager and Ostrom use it to characterize the rights of individual property holders when it is the relationships between different kinds of propertied and non-propertied actors that must be described. Fortunately it is possible to use their typology to classify the rights of each public, common, and private actor before describing their sociolegal relationships as titleholders, proprietors, claimants, authorized users, and non-property holders.

While I am certain that future work will require me to revise Schlager and Ostrom's scheme, I have not found a more productive alternative. I hope to demonstrate that such efforts to operationalize property types can help anthropologists identify and explain the evolutionary trajectories of property regimes. It should be evident that the state, private, and common property regimes are highly abstract and aggregate classes that can easily be broken into sub-classes, but that task must be left for later. With this caveat in mind, we may now briefly examine characteristics of the major classes of property regimes that have been described around the world.

State property regimes are those in which the maximal political authority holds title right to benefits derived from some 'thing'. Its servants (public agencies, ministers, military or religious leaders) have the right to determine who, and under what conditions, specific classes of individuals will gain access, use, and manage the resource. States may or may not delegate usufruct and managerial rights to individuals or corporate groups (Bromley 1991b). The state property regimes among the Egyptians, Chinese, Hundza, Inca, and Aztec hydraulic states described by Wittfogel (1957), Price (1992, 1994, 1995a,b), and Sidky (1996) involve state bureaucracies that developed in broad riverine, semi-arid environments with dense populations, relatively few water sources, and pre-industrial agricultural means of production. These conditions favored the evolution of a despotic rulers who held title rights to water resources and exerted a strong managerial influence over local irrigation communities because the amount of labor necessary to construct and maintain the irrigation networks could only be ensured by the coercive force of a supra-regional political and military authority. Local elites or corporate groups lacked both the material resources or the coercive power.

In contrast, hydro-agricultural societies with relatively decentralized, weak state control over local resources evolved where topography, rainfall, land use, and demographic patterns encouraged more segmented and localized irrigation systems. The states often held title rights to water, but left resource management to local individuals or corporate groups which could construct, operate, and maintain the local irrigation systems because the local groups typically amassed the needed labor themselves. (Wittfogel 1955, 1957; Price 1994, 1995; Sidky 1996; Abruzzi 1993).

State owned and operated water works also exist in industrial societies, but the nature and scope of the relationships between managers, operators, and users is fundamentally different. Industrial water management installations often rely on state funds and frequently employ private firms or common property institutions to manage and operate them rather than corvee labor (Cox 1987, Liecap 1989; Hielman and Johnson 1992; Serageldin 1995; Idelovitch and Ringskog 1995; Ostrom 1994, Ostrom et. al 1990; Price, 1992; Sampath and Young 1990). Although ancient state water management systems may be found through out the world that retain most of their traditional practices, others have undergone enough technological and economic change to thoroughly alter the relationships between water management associations and various kinds of corporate and state agencies (Hielman and Johnson 1992; Serageldin 1995, Idelovitch and Ringskog 1995). In other words, the process of intensification and industrialization has forced water property regimes and management practices to evolve.

Common property regimes are those in which a resource is owned by corporate groups such as lineages, clans, townships, clubs, etc. who possess the title and the consequent rights to use, manage, and exclude 'non-members' (Ostrom 1990, 1994, Netting 1992). The corporate groups establish the institutional means by which they regulate their own internal and external relationships. They create procedures and internal groups to plan, make decisions, monitor the condition of the resource and each other's behavior, settle disputes, take disciplinary action, guide labor activities, and make capital investments (Mabry 1996). Common property regimes are found in state and non-state societies throughout the world. They are most closely associated with pasture, fishing areas, irrigation canals and watering holes, and forests where the: 1) average rate of return to investments is low; 2) yields tend to vary significantly from year to year; 3) the conditions do not favor intensification; 4) large territories are needed for a given level of production; 4) and labor demands and capital investments require relatively large populations (Ostrom 1990; Netting 1981, 1992).

Private property regimes are those in which non-public autonomous actors such as individuals or corporate groups hold the property title. In most cases, the activities private property holders may undertake are limited by informal or formal legal strictures which specify 'reasonable' or 'appropriate' uses. There seem to be a number of different conditions under which private property rights become dominant. Rudmin's (1995) statistical analysis of ethnographic data compiled in the Atlas of World Cultures and the Ethnographic Atlas shows that private ownership tends to correlates positively with the presence of cereal agriculture, large populations, class or caste social organizations, primogeniture, sovereign political organizations, active ancestral spirits and supernatural sanctions for morality

The conditions under which private water property emerges is more debatable Most surface water resources are publically or communally owned even if individuals may hold strongly protected individual usufruct rights to them (Mabry 1996) Dhawan (1988, 1989) and Shah (1993) demonstrates that private property concerning water tends to develop in areas where groundwater pumping is introduced This phenomena has also been observed in the United States, Latin America, and Europe

Again, the degree to which private owners may also be resource managers varies according to the nature and scope of the productive system. For example, social scientists have documented a steadily growing number of cases in which groundwater resources are owned and managed privately by individuals, extended families, or firms. Evidence also demonstrates that privatization in industrial desalination and water reclamation facilities does not necessarily mean that private agents own the resource Instead they may or may not own and operate the facilities that produce water for public and common property institutions who hold the title or concessions to water resources (Hielman and Johnson 1992, Serageldin 1995; Idelovitch and Ringskog 1995)

Most of the existing anthropological research on water property is limited to the extent that it concentrates on pre-industrial irrigation and development programs involving surface and groundwater resources (Mabry 1996). The bias towards non-industrial conditions tends to lead us to pay relatively scant attention to cases in which the modes of production have intensified and shifted to industrial forms. Thus, we rarely see anthropological studies that explain how and why water property regimes respond to international changes in the marketplace, agricultural intensification, urbanization, and technological change.

Were we to conduct more of this kind of research, we would be in a much better position to describe and explain the full range of evolutionary trajectories of water property regimes and management systems as they respond to shifts in the mode of production[1] The primary virtue of such research would be to formulate more general and testable theories about the evolution of property that encompass the specific conditions commonly discussed in anthropological case-studies and theoretical reviews. I suspect that the research would prompt us to re-evaluate theoretically significant factors such as the location of water sources, differences in water quality, consumer markets, economic dependency, disease patterns, warfare, kinship, and indigenous property relations.

Previous Research about Canary Islands Water Management

The Canary Islands may provide us with an excellent opportunity to develop more powerful and general theories because the archipelago offers a great variety of ecological and technological contingencies and property regimes. Water property issues have always generated scholarly interest in the Canary Islands. Jurists examine the characteristics of property rights and property regimes with careful attention to their relationship to other aspects of substantive and procedural law regarding administrative, fiscal, property, and criminal activities (see the following for an introduction: Gay de Montella and Masso Escofet 1956; Guimera Peraza 1957; Ramírez Suárez1962, Ascanio 1989, Ascanio y León 1926, 1989; Cuetara Martínez 1990; García Padrón 1982; González Sanfiel 1993). Hydro-geologists, biologists, and agricultural scientists have worked with historians, engineers, geographers, economists, and social anthropologists to conduct summary and case studies of water resources and management.[2] Their work makes the Canary Islands one of the most clearly described archipelagos in the world. Just as importantly, the Spanish bureaucratic traditions make it possible to collect information about the causal factors and the dynamic processes that selected for water property regimes over the past 500 years.

Unfortunately, some of the theoretical and methodological difficulties I raised above and competing economic interests have clouded attempts to describe and explain the evolution of water property regimes in the archipelago. Despite the existence of excellent studies which demonstrate that it is possible to explain the evolution of water property rights regimes primarily as a response to external market and insular techno-environmental conditions (Hernández Ramos 1954, Reyes Aguilar 1989; Quirantes 1981; Batista 1994, nd a, nd b; Aguilera Klink 1994; Rodríguez Brito 1995), many of the participants in the current debates continue to treat ongoing reforms as part of a political battle between elites or proponents of fascism, capitalism, socialism, and democracy.

Field Research on Gran Canaria

This study is based on 18 months of archival and ethnographic fieldwork conducted between February 1994 and September 1995. I went to the Canary Islands with the intention of determining how the Canary Island Water Law of 1990 affected efforts to conserve the aquifer while increasing water quantity, improving its quality, and controlling prices. Most of the island's water and water technology had been owned and managed by private groups since the 1930s. The controversial water law declared water to be part of the public domain, but allowed private owners with significant amounts of water to chose one of two options during a long transition period.

Nearly all of my informants claimed that the Water Law of 1990 was in limbo and no changes had come about because powerful water owners and vendors were resisting reforms and because, aside from ever present government incompetence, bureaucrats were struggling for power and access to Spanish and European Community funding. Yet the more I surveyed the situation, the more apparent it became that significant changes in water management were taking place even though the institutional agent of change had been largely stymied. New and unanticipated property regimes were emerging as public and private institutions modified their statutes, practices, and relationships.

When I confronted water owners, users, and public authorities alike about this apparent contradiction, many explained that the changes were not really caused by the water law. Other things were occurring. If taken as a whole, the informants underscored the significance of long-term historical changes in: water technology; international market opportunities; class conflicts; the structure of the civil administrations, competing political ideologies, morality, and the psychological predisposition of agrarian and insular peoples. This is a rather eclectic list of factors causing the evolution of water property, and cannot lead to a sound testable theory.

I argue that if viewed as a part of a long process of sociocultural change, the evolution of water property regimes in North Central Gran Canaria becomes understandable as a series of fundamental adjustments to external market opportunities and techno-environmental factors as the island's mode of production shifted from hydro-agriculture to industrial agriculture to urban economy based on tourism. Each period was marked with significant legal challenges and social conflicts as property regimes evolved even though the courts and formal laws nominally protected the existence of established property regimes.

Location

The research area covers part of a water catchment basin that cuts across six northern municipal districts: Valleseco, Moya, Firgas, Teror, Arucas, and Las Palmas (Figures 1-1; 1-2). I focused on the north central region catchment basin because the first water-users organizations were largely limited to irrigating lands within them. This north central region was especially interesting because some of the island's most important, and well documented, water users associations had operated in it. I narrowed the focus of my research to Valleseco, Firgas, and Arucas, and to a limited extent Teror, because these municipalities encompassed the bulk of the catchment basin's surface area. I decided not to conduct many interviews or do archival research in Teror simply because I had only enough time to work in three of the four municipalities and felt that the water management histories of Valleseco, Firgas, and Arucas were more accessible.

Since the irrigation systems grew to exceed the bounds of water basins by the turn of the 18th century and are now taking on insular dimensions, many of the events and processes occurring in the

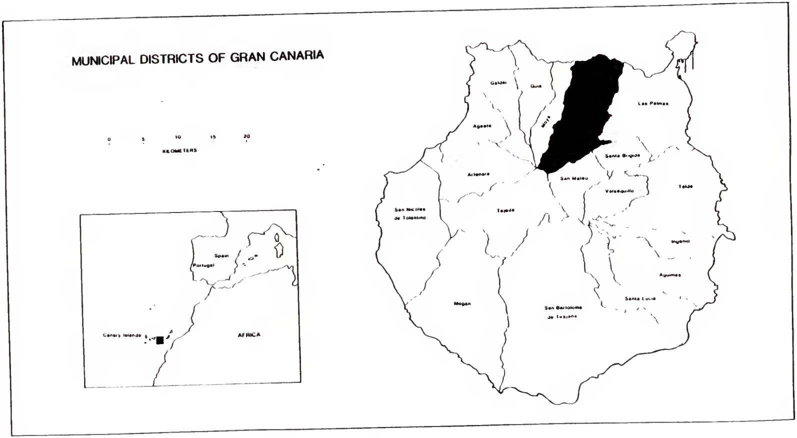


Figure 1-1 Municipal Districts on Gran Canaria

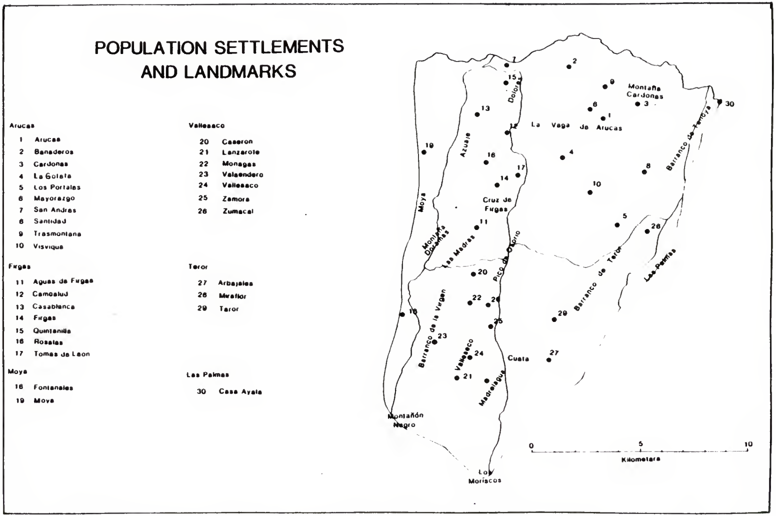


Figure 1-2 Population and Settlements in North Central Gran Canaria

north central region are intimately connected with events and trends elsewhere. Therefore, I interviewed people from nearly every municipality on Gran Canaria. In addition, I traveled to Tenerife, Madrid, and Brussels, Belgium to trace the links between local water users associations and Spanish and European Community regulatory and funding agencies which are providing or soon will provide monetary support for them.

I lived in three places during the field research. I stayed in Las Palmas between February 19 to June 22 while doing library and archival research, conducting interviews, and generally getting my bearings. I lived in Valleseco from June 22nd until October 15, 1994 in order to learn about where most of the water in the watershed originates. Once my work in Valleseco's municipal archives was nearly complete, I moved to Arucas and repeated the process. During the summer, I often made trips to Valleseco and Firgas to collect more archival documents, conduct interviews, and to visit friends. I returned to the United States on September 22, 1995.

The large research area and the nature of the subject created severe logistical problems; transportation was time consuming and the work load was far too much for one person. I decided early on it was more important to stay in the field 18 months than it was to travel quickly. Rather than buy a car or moped, I walked, hitchhiked, took buses, and caught rides. In retrospect, it was the right decision. Informative, friendly people spoke with me about water management and everybody, it seemed, gossiped about everyday situations. I stayed in the field through most of 1995 and observed several important events, including: one of the worst droughts on record; the creation of the Insular Water Council; a biannual meeting of professional water managers (CANAGUA); the formation or reformation of several water users associations; and the publication of the PRECAM 2000 study which compiles plans for future government subsidized reforms and capital investments for irrigation. Since then I have taken advantage of the World Wide Web to read Canarias7, a Canary Island newspaper which often carries stories about fiscal, political, economic, and hydrological matters specific information about their own costs of production, membership, etc..., they all suggested I meet informants along the canals, in farmer's meetings, on the streets, and in bars. I took their advice, and met many extraordinary, unforgettable people. If you think of the search procedure in terms of a social network, the snowball technique lead to the most powerful actors (individuals with large water holdings, vendors, administrators) in the hydraulic system while the convenience technique facilitated contacts with relatively weak actors (farmers with relatively small amounts of water, retired farmers, and employees).

Elderly men know the most about water management, but do not react well to questionnaires or formal, recorded interviews. Therefore, I adopted five interviewing tactics.

1. I initiated conversations with strangers by making an observation or asking a question. If the person volunteered more information than necessary, I introduced myself and explained that I wanted to learn about changes in water management and how the Water Law of 1990 would affect them.

2. I did not usually ask people their names. An informant's name can be a potential weapon. People might not want to speak about the subject if probed for information that could identify them as its source.

3. An even better way to facilitate conversation was not to record informants or take extensive notes in public. Some people explicitly said they could not broach sensitive topics if recorded. Many more expressed their discomfort. So I taped only nine conversations and often jotted down notes after conversations. Whenever possible, I took notes on the spot and encouraged informants to draw pictures and maps, make lists, and do calculations in my note book.

4. I also tried to hold interviews with individuals or groups of 2 or 3 persons in quiet places. Large groups in busy streets inhibit frank discussions about sensitive topics. That does not mean that the interviews were held in secrete. Far from it. Retired or semi-retired farmers and laborers congregated in public places so most of the interviews were done along canals and in fields, streets, public buildings, and bars. On occasion, especially motivated farmers talked about their water problems in front of as many as 15 others. Usually one or two of the listeners joined the conversation.

A second logistical problem was the work load itself. There was simply too much for one person to do. Fortunately I hired an excellent co-worker. Angel Garcia Gris worked with me on a part-time basis between June, 1994 to September 1995 while he attended the Universidad de Las Palmas. Angel, who is now a practicing civil engineer, helped me understand hydrogeological and engineering concepts and bureaucratic processes that I had not studied in my own graduate courses in ecological engineering. Furthermore, he collected data, conducted interviews, calculated water availability (García Gris and Byrne, 1995), taught me ways to navigate the Canary Island bureaucracies, and made or traced maps of the region's intricate rainfall pattern and water conveyance network.

Interviewing

Water management is a sensitive and secretive subject because its practices and rules often differ from formal law. Sometimes the activities are blatantly illegal and violate local moral codes of justice. Other times the distinctions are murkier. Either way, publicly acknowledging one's own activities could jeopardize legal proceedings or initiate them. Therefore, I abandoned my plans to conduct archival research in water users associations; use formal questionnaires, conduct much participant observation; and use a proportionate-to-size random sampling strategy to find informants. Instead I conducted opportunistic informal or formal interviews and mined public archives for relevant information.

Finding informants was not a big problem despite the lack of reliable public lists of associations or owners to construct a sampling frame. All I had to do was use a mixture of snowball and convenience procedures. Informants usually directed me to a small group of well-known water owners, vendors, and administrators when I asked, "Who could teach me more about...?" Several of the most powerful and/or well informed individuals patiently explained, in general terms, how their associations operated and the problems they must solve. Since they were rarely at liberty to provide

> 5 Most of the interviews lasted as long as a normal, informal conversation, anywhere between 5 minutes to two hours. I did follow-up interviews whenever possible. Since the convenience sampling strategy and tight schedules among the informants meant that there would probably be only one interview, I focused on what they claimed they knew best.

Informants described and explained how their water management practices and property relationships had changed during their lifetimes, described their current situation in general terms, and speculated about how current legal reforms might affect them. Yet, only a few could describe the hydraulic system itself or talk about legal and social conflicts in any detail. Some of that information rests in government archives.

Archival Sources

I collected maps, surveys, descriptive and statistical information, as well as legal and administrative documents from: the Municipal Archives of Valleseco, Firgas, Arucas, Teror, Guia-Galdar, and Las Palmas; the Ministerio de la Política Territorial; Ministerio de Medioambiente, Ministerio de Agricultura, Pesca, e Industria; Dirección General de Aguas and the Consejo Insular de Aguas; the Consorcio Insular por el Aprovachamiento de Aguas Depuradas; the CANAGUA water conference; the Museo Canario; the Universidad de Las Palmas de Gran Canaria and the Universidad de La Laguna; the La Provincia, Canarias7, Diario de Las Palmas newspapers; and the European Community.

Data Analysis

This dissertation will not present many statistical tests because they would only be misleading. The data concerning agricultural and water production, water prices, and title ownership are not reliable. Moreover, there is no point in pretending that I have a statistically representative sample of informants. When necessary, I will highlight particularly incongruous data and speculate about the cause, direction, and magnitude of their biases. Fortunately, the key evolutionary transformations shine through imprecise and biased data.

Outline

Again, my general thesis is that changes in economic opportunities that are produced by external markets and local techno-environmental conditions periodically set off a chain of modifications in labor requirements and demographic patterns that alter the ability of competing groups to exploit the island's water resources. The evolution of the property rights and their distribution depends on the degree to which competing individuals and groups can make capital investments and then defend their claims and facilities -- and not on the inherent qualities of each of the property regimes, formal law, or political ideology. An analysis of the evolution of water management and property regimes in the north central region of Gran Canaria provides us with a test of my general model.

The dissertation is divided into three parts. Each part reflects what I consider to be different eras in water management. Part one describes and explains the evolution of property regimes during the era of surface water when the agrarian population relied on rainfall, surface runoff, and spring water. Chapter Two describes the techno-economic conditions giving rise to the colonial society. Chapter Three is divided into two main sections. The first part focuses on the establishment of property regimes and water user organizations called heredades and sub-acequias evolved during the formation of the colony. The second examines how and why the heredades evolved and why comunidades de regantes and ayuntamientos were founded.

Part Two focuses on the industrialization and modernization of water production between the 1920's and 1990's. Chapter Four explains how and why the rise of the European agricultural markets lead to capital investments in groundwater mining technologies and shifted the control over the islands resources to a new form of water users organization called comunidades de aguas. Chapter Five discusses how and why the consequent adjustments in the location of production, property regimes, and distribution networks affected the regional water markets.

Part Three reviews the transition to a new era in water management. Chapter six outlines the consequences of aquifer overdraft, urbanization, and the collapse of agriculture during the 1970s and 1980s. It also concentrates on the relationship between the ayuntamientos, farmers, water owners, and vendors. Chapter seven discusses debates over water law in the context of the efforts to adopt desalination and water reclamation technologies during the democratization of the Spanish state and its incorporation into the European Community. Chapter 8 describes some of the current water management reforms. I conclude in Chapter 9 by briefly reviewing my argument and discussing some of the theoretical implications of this study for research on the relationship between property regimes and resource management.

Notes

1.

There is a huge literature describing the many water management practices and property regimes found throughout the world. For a tiny sample, see Abruzzi 1993, and Aguliera Klink and Nunn 1989, Blomquist 1992; Cox 1987; Chambers 1980, 1988; Coward 1980, 1986, 1991; Easter and Hearne 1994, Emel 1987, Falkland 1991, Freeman 1989, 1991; Glick 1970, 1972, 1995; Hanna and Munasinghe 1995; Higginson and Barnett 1984; Hunt 1978, 1978, 1988, 1990; Hunt and Hunt 1974, 1976; Maas and Anderson 1978; Mabry 1996; McCool 1995; Netting 1974, 1981, 1992; Price 1992; Steward 1955 Trelese 1977; Wade and Seckler 1990; EPA 1992; Viessman and Welty 1985; Viessmann and Hammer 1992; and Wittfogel 1955, 1957.

2.

See: Torriani (1978) [1592]; Chil y Naranjo (1876; Abreu Galindo (1977); Ascanio y León, 1926; Hernàndez Ramos 1946; Hausen 1951; Benítez Padilla 1959; Kunkle 1976; Glick 1972; UNESCO 1974; Tudela Galván 1980; Martín Martín 1991; Brier y Bravo de La Laguna 1981; Camps de Betencourt 1981; Clavijo 1981; Hernández and Pérez 1981; Quirantes 1981; Comisión Mixta Para la Planificación Hidrólogica en las Islas Canarias 1982; Fernández Armesto 1982; Rodríguez Brito 1986, 1992, 1995; Suárez Grimón 1988, 1990, 1993; Díaz Rodríguez 1989; Aguilera Klink et. al 1994; Batista Medina 1991, 1995; and Rosa Olivera 1981, 1994 for just a tiny sample of the studies that have been done.

CHAPTER 2

THE AGRO-ECOLOGICAL FOUNDATIONS OF GRAN CANARIAN SOCIETY (1483-1930's)

In conformity with my general model, I argue that the European demand for sugarcane during the age of exploration and colonial conquest led to the creation and institutional design of the colonial Canary Island societies. The local techno-environmental characteristics shaped the seasonal and spacial availability of resources such as water, soil, sunlight, as well as the archipelago's critical place within the expanding colonial trade routes. The demand for labor led the colonists to enslave many of the indigenous Canarios, acquire West African slaves, and hire free Christian journeymen. Most people lived along the coast which was the center of export production. The requirements for efficient and profitable sugarcane production forced the state to divide land and water resources among conquering colonists. The distance between the Crown and, thus, its inability to directly oversee local events, forced the state to grant colonists a variety of usufruct water property rights and to help them create self-sufficient water-users associations. Consequently, the colonial society quickly became stratified according to the colonists' ability to make investments in sugarcane, to command labor, and to possess land and water resources.

Over the next four hundred years, fluctuations in the international economy and the water and labor requirements of agricultural species imported from Africa and the Americas placed the Canary Islands in direct competition with other colonies for the European markets. The archipelago's economy followed a boom/bust cycle characteristic of economically dependent societies that specialize in mono-cropping (Sanderson 1995). The boom/bust cycle and the location of the water sources encouraged sporadic investments in the production of grapes, cochinilla, and more recently, corn, potato, banana, tomato

The advantage of my general model is that it predicts that when change like these occur, modifications in the property rights regimes can be expected to follow Indeed, as I will demonstrate in the next chapter, the property regimes did change despite repeated legal decisions by the Spanish state that favored the status quo. Not only did the state gradually loose control over the island's water resources, individuals with usufruct rights increasingly transferred their rights independently of land. In addition, conflicts between residents in the highlands and the lowlands over highland water sources became endemic during the 17th to 19th centuries. The conflicts are directly implicated in the formation of highland water users organizations and the formation of municipal governments and comunidades de regantes.

The Expansion of the Spanish State into the Canary Islands

The study of water management in the Canary Islands begins in the Iberian peninsula. Glick's (1995) survey of Medieval Spain shows that Spanish colonial water laws and practices developed from a collection of Islamic, Roman, and mediaeval Spanish laws and management practices. Spain emerged as a powerful decentralized colonial state as it expelled most of the Moors from the Iberian peninsula during the 15th century. After gaining military control over trade networks, port towns, and irrigated valleys, the Crown redistributed land and water rights among loyal subjects in a process known as the *repartimiento*.

The process itself varied throughout the empire. The Spanish state and colonialists modified the repartimiento, property regimes, and irrigation communities according to the natural conditions, technical options, and economic opportunities they encountered (Glick 1970, 1972, 1995) On the

Spanish mainland, the Crown often maintained local customs whereby Moors who converted to Christianity remained in possession of their lands and water. Although most of the water in these areas, in particular along the eastern and southern coast of the peninsula, had been considered public and managed by irrigation associations, there is some evidence that landowners acquired proprietary, if not ownership, rights to water during the height of the Moorish period (Glick 1995). As the crown expanded its influence through Andalucia, Granada and the Canary islands, it occasionally granted inalienable property rights to land and water along with political jurisdiction in Granada, and in two cases, the Canary Islands. As a general rule, however, the Crown granted settlers in the Canary Islands titles to land along with a variety of usufruct rights to water.

The Canary archipelago is a perfect example of Spain's attempt to create a thriving colony where the infrastructural and structural conditions did not yet exist. Chroniclers from Egypt, Phoenicia, Greece, Rome, and Berber regions referred to the archipelago as the *Islas Afortunadas* (Fortunate Islands) or Canarii and became Spain's first major oceanic territorial conquest. Resting 115 km due west of Morocco, the archipelago consists of eight small inhabited islands and 9 uninhabited islets (Kunkel 1976). The eastern desert islands of Lanzarote and Fuerteventura were sparsely populated. Gran Canaria and Tenerife were both populous, well-watered, forested islands. Beyond them, La Gomera, El Hierro and La Palma had even more productive ecological settings, but were too small to support large populations.

European kingdoms had been trying to conquer the indigenous populations of the Canary archipelago for about 200 years in the 1480's when the Spanish finally incorporated it into their Kingdom. Like the French, Portuguese, and Catalans before them, the Spanish subsidized conquistadores. The conquistadores, who had made personal investments in the campaigns, welcomed the aid but struggled with the Crown and Church for control over the territory. The Crown quickly legitimated and asserted its political authority by naming the foremost conquistadors as their colonial

Gobernadores (Governors), *Coregidores* (Magistrates), and Captains. They soon replaced the first governors, established colonial governments, and promoted economic growth by distributing land and water rights among colonists (Fernández Armesto Fernández Armesto 1982, Azanar Vallejo n d).

This pattern is evident on Gran Canaria. The crown named Pedro de Vera as Governor in 1480, three years before the final victory over the indigenous Canarios and permitted him to wield nearly absolute power for 12 years. The Catholic Monarchs replaced him in 1492, five years after incorporating the archipelago into their realm. They and their hand picked governor, Francisco Maldonado, formed an insular government called a *cabildo* in 1494. I wish to pause here to explain that in most Latin American areas, cabildos are town councils, but their jurisdiction in the Canary Islands encompasses the islands on which they are located. The *cabildo insular* on Gran Canaria included six publicly elected scribes, a treasurer, supervisors of public works, one representative for commoners and another to represent the council's interests. The *alcaldes* were appointed to hear civil and criminal cases and were authorized to enforce their decisions. More serious conflicts were heard by the regional court called the *Audiencia* and the Crown itself. The new system augmented the Crown's relative power with respect to powerful landowners and the church (Fernández Armesto 1982).

The Crown stimulated immigration to the far reaches of its expanding empire by lifting travel restrictions within its realm and holding out the potential to acquire property. Immigrants from Castilla, Granada, and Andalucia, joined with the French, Portuguese, Genoese, Italians, Catalans, and Basques and quickly built prosperous sugar and merchant shipping industries. Non-Spanish colonists had grown so affluent and powerful by 1499 that the Crown checked their growing influence; it responded to complaints that the Genoese controlled over half of the arable land on Gran Canaria by restricting immigration and limiting the amount of land any "alien" could possess. Three years later, it blocked the immigration of free Berbers, Moors, Moriscos, and Negroes who lacked a royal license

These prohibitions, the destruction of the pre-Hispanic Canarios, the severe poverty and famine which were partly caused by the sugar industry, and the promise of wealth in the New World, slowed immigration and actually encouraged some emigration so that the archipelago's population leveled off to 35,000 by 1587 (Fernandez Armesto 1982). Half of the colonists in the archipelago lived on Gran Canaria because it was the second largest island and had some of the most promising agricultural conditions (Arbelo García and Hernández González 1988).

Ecological Conditions

Gran Canaria was especially attractive because its relatively large size, topography, weather, fertile soils, and flowing rivers made it a miniature continent replete with semi-tropical coasts, dense temperate pine forests, tundra, arid valleys and coastal deserts (Torriani 1978). The base of the island is a fascinating mosaic of volcanos, lava and ash-flows, outcropping, fissures, and dikes. A subterranean fault divides the island along a North West to South East axis and deflects volcanic activity towards the northeast. Most of the island's 99 volcanoes are located in the north. They form fertile hills and outcropping in the 24 steep valleys that radiate outward from the center of the island (Figure 2-1). Coastal planes ring most of the island, except in the south-western quadrant where immense jagged cliffs meet the ocean's pounding surf (Araña and Carracedo 1978; ITGME 1990; Schmincke 1976:127-132).

The island's topography and the westerly oceanic and atmospheric currents rushing past it create seasonal fluctuations in temperature, humidity, and solar radiation. The temperature and humidity vary according to altitude and the orientation of the island's surface. Low-altitude trade winds buffet the northeastern side of the island, absorb evaporating seawater, rise, and mix with the warmer and drier Saharan and anti-trade winds blowing from the Southeast. Cloud banks form at 1000 meters and are pushed downward by anti-trade winds (Fernadopulle 1976; Simons 1992). To a person looking

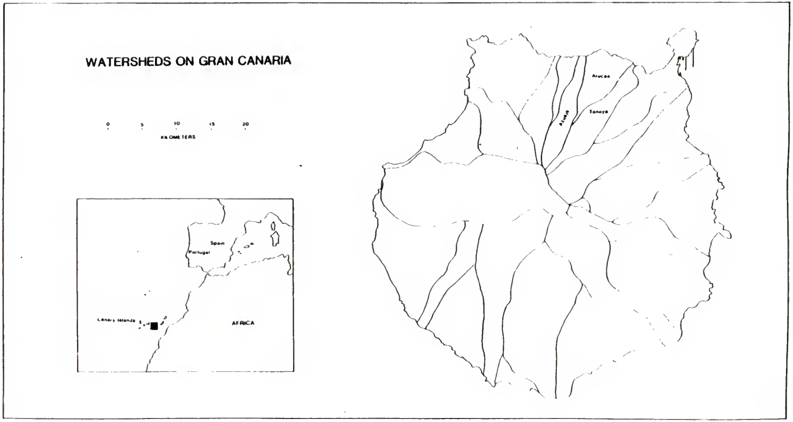


Figure 2-1. Watersheds on Gran Canaria

out to sea from the highlands, the cloud banks appear to form a *mar de nubes* But to anybody along the coast, they hover ominously like a great *panza del burro* (donkey's belly). The clouds wash ashore in the *medianía* (midlands between 300-1000 meters) and *cumbre* (1000 meters and above) during the late afternoon. Their cool, misty precipitation called the *bruma*, *nublina*, or *lluvia horizontal* (horizontal rain) is sometimes so thick it is impossible to see beyond 100 meters.

Valleseco typically sees temperatures fluctuate between 0° and 20°centigrade during the winter and 15° to 30° during the summer. The weather conditions in the *medianía* are slightly warmer and more stable. The temperature fluctuates between 10° to 15° degrees, but again, it changes quickly from a dry heat to a dreadful humid chill whenever the *mar de nubes* comes a shore. Even though the weather in both the cumbre and medianía may seem unfavorable, anybody driving through the area after a misty rain in April will be struck by the luxuriant, brightly colored flowers that blossom against a rich green sea of bushes and terraced fields. In comparison, it is the relatively arid and warm coast line that seems least favorable to vegetation. Indeed, most of the indigenous species are highly adapted to water scarcity and all of the farms depend on irrigation.

The average temperatures obscure the dynamic nature of the climate. The temperature, wind and humidity in the *cumbre* can make local conditions change from dreadfully hot and dry, to cool and refreshing, and again to bone-chilling in less than an hour and even across short distances. The air currents are so dynamic that you can literally feel small differences in temperature on different parts of your body.

The seasonality, amount and distribution of rainfall also seems relatively constant when examined over the span of years, but belies large variations and, hence, unpredictability. More than half of the rain falls between October and February and 30% between late November and early January. Misty showers follow in March and April. In exceptionally rainy winters like 1996, Canary Islanders rejoice as flash floods run through all of the valleys filling reservoirs, dams, and tanks before spilling into the ocean. But, as often happens, winter droughts force farmers and urban settlements to endure great hardships.

On average, Gran Canaria receives 300 mm or 466 Hm^3 of rain every year. However, the island has received below average rainfall in most years since 1950 (Fernandopulle 1976, Marzol Jaen 1988, Consejo Insular de Aguas de Gran Canaria 1995; Rodriguez Brito 1995). Most of the rain falls in the *cumbre* on the northern side and least along the southern coast (Figure 2-2). The northern coast receives about 168 mm/yr of rainfall while 1,100 mm/yr falls in the *cumbre*. The southern desert coast is sprinkled by only 92 mm/yr Fernadopulle 1976.197, Marzol Jaen 1988). An estimated 162 Hm^3/yr evaporates and 75 Hm^3 (16%) forms torrential seasonal rivers that run down the valleys to the ocean. Only 87 Hm^3 (12%) filters into the soil. Of this, 40 Hm^3/yr flows through underground streams to the ocean. The evapotranspiration, surface runoff, and subterranean drainage leave just 47 Hm^3/yr (10%) to recharge its aquifers (MOP 1974; Consejo Insular de Aguas 1995).

Spanish colonists were drawn to the northern half of Gran Canaria precisely because the remnants of its aboriginal population, flowing spring and rain-fed rivers and dense pine forests provided the resources they needed to produce sugar. In comparison with the other regions of Gran Canaria, the north central region is blessed. The area forms a triangle 71 Km^2 that stretches from the Barranco de Azuaje and the Barranco de Arucas along the coast to a peak near the center of the island. The western boarder ascends from the Barranco de Azuaje (Azuaje Valley), through the Barranco de Las Madres, Oscuro, La Virgen and El Andén, and La Retemilla up to Montañón Negro. On the eastern side, the Barranco de Arucas rises from the coast to the Pico de Ossorio where it meets Teror and Firgas. The boundary between Teror and Valleseco unites at the Pico de Ossorio and runs along Lomo de Madrelagua in Valleseco. The boundary between Valleseco and Firgas is located at the point where the Barranco de la Virgen converges with the steep forested banks of El Rapador and Casarón. The area amounts to 6.3% of the land mass, but receives 10% of the rain (Table 2-1). An average of

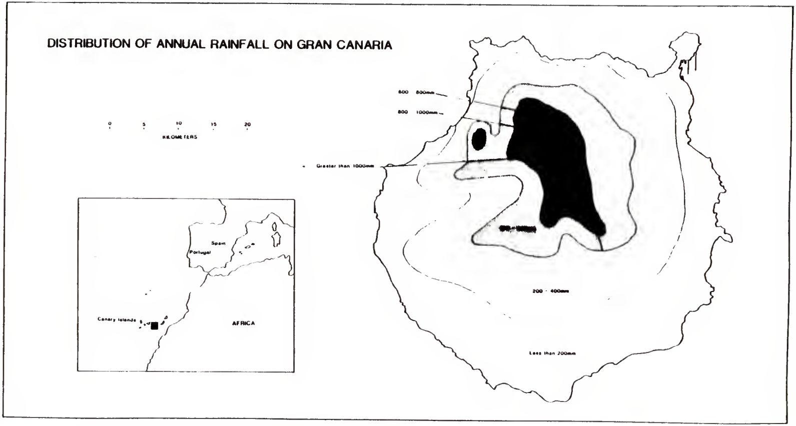


Figure 2-2. Distribution of Annual Rainfall on Gran Canaria

Table 2-1 Annual Rainfall, Evapotranspiration, Surface Runoff and Infiltration by Region

Catchment Basin	Area Km^2	Rainfall Dm^3	Runoff Dm^3	Infiltration Dm^3	Number of Springs in Each Municipality	
Valsendero-Azuaje	27.51	19,905	3,804	3,163	127 15	Valleseco Firgas
Madrelagua-Tenoya	36.27	18,352	3,507	2,916	14 ?	Valleseco Teror/ Tenoya
Arucas	34.13	11,020	1,203	1,000	11	Arucas
Total	71	49,277	5,814	7,079	167 +	

Source: García Gris and Byrne (1995)

8,514 Dm^3/yr of surface runoff flows from the *cumbre* to the ocean as another 7,079 Dm^3 recharges the aquifer (García Gris and Byrne 1995).

As you might expect in an island with such pronounced micro-climatic conditions, the rainfall pattern varies within the region itself and must be examined carefully because, as I will show later, it influenced how the Spanish distributed property rights to local water sources. The first zone covers two of the three principle valleys in Valleseco (Madrelagua, Valleseco, and Barranco de la Virgen), roughly half of Firgas, and a thin coastal strip of Arucas at San Andrés. Although it is 27.51 Km^2 and represents 1.77% of the island's landmass, it receives 4.26% of its rain (García Gris and Byrne 1995). Most of the 19,905 Dm^3 rainfall falls in the *cumbre* in and around Valleseco and evaporates immediately Roughly 3,804 Dm^3 flows from the steep valleys below Montañón Negro through El Anden, the Barrancos de la Virgen and Valleseco, past Zumacal, El Rapador, la Montaña de Firgas, and all the way through the Barranco de Azuaje to the coast. The rest, 3,163 Dm^3, filters into the soil.

The second area covers 36.27 Km^2 or 2.33% of the island's landmass. Its western border descends from Los Moriscos to the Pico de Osorio where it veers to the east, through the Barranco de Tenoya and ultimately to the northern coast. This water catchment basin overlays Teror, Valleseco, Las Palmas, and borders Arucas. Its 18,352 Dm^3 of rain amounts to 3.92% of the island's rainfall. Again, the heaviest precipitation occurs in the highlands around Valleseco. An estimated that 3,507 Dm^3 runoff flows through the Valle de Los Moriscos, down the Barrancos de Charquillos and Madrelagua, past a narrow passage in La Cueta to Teror, and down the Barranco Tenoya to the ocean. Valleseco controls the upper reaches of zone two. Teror has jurisdiction over the middle ranges, and both Arucas and Las Palmas oversee water passing along their borders in the Barranco de Tenoya. The local recharge rate is about 2,916 Dm^3/yr.

The third area forms a triangular catchment area whose upper tip is the Pico de Ossorio. Its northwestern boundary runs along Montaña Firgas and through Casablanca. The other border runs through Santidad, just east of Montaña de Cardones, and reaches the ocean between Punta de Arucas and Barranco de Tenoya. This coastal area is 34 13 Km^2 and represents 2 2% of the island's surface It receives 11,020 59 Dm^3, or 2 36% of the island's rainfall. Its relatively small yearly recharge rate of 1000 Dm^3 is welcome.

The rivers flowing down these valleys were not entirely dependent on any single winter's rain. The unpredictable yearly swings between severe drought, disastrous downpours, or average winter rains and arid summers made artesian springs the most reliable source of water. The springs formed where relatively younger and porous basaltic formations lay on top of older, less porous formations Approximately 15% of the rain filtered into the soil and resurfaced in artesian springs months or years later. In many cases, dykes and impermeable beds called *aquicludes* often formed underground pools that seeped out at relatively low rates, guaranteeing a steady flow of water for years after the last rain. Nobody is certain how many springs existed on Gran Canaria at the time of the conquest Municipal surveys conducted in 1944 record 134 springs in Valleseco, 15 in Firgas, and 13 in Arucas Of those, at least half were located in the Barranco de la Virgen, Las Madres, and Azuaje. Another 53 were spread through out Madrelagua, Cuevacillas, and other valleys in Valleseco.

It may seem odd that a municipal district called Valleseco should have so many springs and be one of the coldest, rainiest areas on the island. Even the residents jokingly call it Vallemojado (Wet Valley) during winter and historical texts sometimes referred to it as Valle Verde (Green Valley). But the name is no misnomer; the valley for which the municipality takes its name is drier than the other two principle highland valleys, Madrelagua (Mother of the Water) and Barranco de la Virgen. Valleseco has just a few springs and rain quickly evaporates or percolates into its porous soils so there is relatively little water available for human consumption.

The Agro-Ecological Foundations of the Insular Economy

Although the popular term for the pre-Hispanic populations in the archipelago is 'Guanche, archaeologists and historians call the pre-Hispanic inhabitants of Gran Canaria 'Canarios.' Early accounts by Spanish conquistadores and colonists estimate that the Canario chiefdom had a population of about 10,000 during the mid- 15th century (Jiménez González 1990; 1992). The island's topography and hydrogeological processes caused pre-Hispanic and colonial inhabitants to settle where seasonal and permanent spring fed-rivers flowed from the steep highland valleys to semi-arid alluvial planes. The Canarios practiced a form of transhumant pastoralism, occupying permament settlements along the coast during the winter and more temporary settlements in the highlands during the summer (Jiménez González 1990; 1992). They cultivated wheat in the coastal planes, fished, and hunted lizards and birds, and herded goats. Apparently, their production of wheat was great enough and demand was intense enough that armed guards stood watch over the surpluses that they stored in pits located in caves and rock shelters. They ground the wheat into a nutritious mash called *gofio* which is still a staple food among older Canary Islanders. They also used local lichen to produce natural dyes for tattooing and other forms of decoration which may have marked lineal and clan affiliations. There is some ethnohistorical evidence that they occasionally traded with merchants from the Mediterranean basin and West Africa; the merchants had to sail to the archipelago because the indigenous populations did not make seafaring vessels or engage in intra-archipelago trade.

The European and North African colonists who replaced the Canarios in the 15th century introduced flora and fauna from both the Old and New Worlds and built their society on intensive irrigated agriculture, herding, fishing, crafts, and oceanic commerce (Fernández Armesto 1982, Crosby 1985). By the early 16th century, colonists tended pigs, cattle, sheep, chickens, kept bees, and struggled to control the population of rats and feral rabbits. Farmers introduced sugar cane, grape, tomato, grape, banana, nopal cactus, corn, legumes, potato, figs, apricots, limon, apple, walnut, among other foodstuffs. Farmers prepared soils by spread *estiercol*, a fertilizing mixture of cow dung, ash, and hay, over the fields one to two weeks before planting.

The agroecological conditions created a vertical spectrum of agricultural activities (Dirreción General de Obras Hidráulicas 1982; Fernández Armesto 1982). Farmers take advantage of the winter rains by planting hearty legumes, grasses, tubers, leafy vegetables during the fall (Aguilera Klink et. al. 1994). They get two crops of potatoes in every year by planting in September, harvesting in January, and planting another crop to be harvested in late May or June. Since land parcels are highly fragmented in the highlands, and must be fallowed, farmers always fertilize the soil before planting again, if they do not leave it in fallow. They plant tomato, corn, onions, kidney beans, squash anytime between March and June and harvest them between June and August. Other crops such as orange, limon, apples, figs, walnuts etc.., must be planted at least 9 months to five years in advance and bear their fruit between August and early October.

The coastal lands are usually dedicated to irrigated export crops like sugar cane, grape, nopal cactus, banana, papaya, tomato, and flowers but also include most of the crops grown in the highland. Banana is currently the most important crop grown along the coastal region. It is very sensitive to humidity, temperature, sunlight, soil composition, and wind patterns. The warmest and most humid region lies below 150 meters and produces the best bananas. But the crops are frequently damaged by the strong winds that blow salt from the ocean onto the soils. The area between 150 and 200 meters which is also relatively warm and humid is optimal for bananas. The yields and quality, however, decline in farms located over 200 meters where the temperature begins to drop (Dirreción General de Obras Hidráulicas 1982).

Irrigation Techniques

The Canary Islanders used two irrigation techniques prior to the mid- 20th century. The *surco* technique is still used for crops planted in furrows such as legumes, tubers, shoots, and grasses such as sugar cane, wheat, potato, corn, beans, and squash. The furrows are typically linear mounds 10 to 20 cm high and spaced 20 to 30 cm apart. All of the furrows are capped by small earthen irrigation ditches at each end. Farmers use short handled hoes with curved triangular metal heads called *azadas* to open and close individual furrows. They start at the furrow closest to the source of water, create a small mound to block off all but the uppermost furrow, and flood it. Then they block off the furrow with the mound of dirt blocking the irrigation ditch and move the mound of dirt blocking the next furrow 90 degrees to block off the rest of the irrigation ditch.

The *manta* (sheet flooding) irrigation technique is typically used in plots growing fruit trees. Farmers build circular, square, or rectangular mounds of dirt around the cultigen and prepare the soil by breaking up the floor of the depression. They then guide water through complex networks of irrigation canals, earthen ditches, or hoses and flood the individual depressions. Both techniques loose at least 30% of the water to infiltration. Although the techniques may seem wasteful, they provide the soils with critical minerals that the water carries, rehydrate the soil, and prevent desertification.

The Sugar Industry

Of all of the possible agricultural options open to colonial farmers, sugar cane was the most lucrative. Encouraged by the stunning success that the Portuguese enjoyed in Madeira, Canary Islanders immediately planted sugar cane along the coast between Telde to Agaete. Landowners hired skilled carpenters, overseers, and mill masters to construct wooden, stone, and earthen *acequias* (canals), houses, storage facilities, vehicles, plus mills powered by *molinos* and *trapiches* (mills powered by water and traction animals). Farms large enough to have a mill employed more than 20 seasonal and permament *cañavereros* (sugar-workers) to build and maintain *acequias* as well as to prepare fields, plant, weed, irrigate, hunt rats, harvest, and process sugar cane. Farm owners relied on indigenous and African slave labor When necessary, they hired free Christians (Bergasa Perdomo and González Viétez 1995). The free laborers were paid in cash, in-kind, and sometimes provided with usufruct rights to land and water The exact payments probably varied, but there is evidence that some land owners paid laborers as much as 50% of the sugar harvested.

Milling was even more expensive than cultivation. The mills often consisted of three buildings, one to house merchants and farmers, another to store the produce, and a refinery The buildings were constructed out of heavy stone, mortar, wood, metal, and ceramic. Most straddled canals called *acequias* The water rushing through the acequias spun water wheels that, in turn, rotated heavy millstones. The largest expense seems to have been wood. The mills required vast amounts of wood for building material, and even more for fuel. There were 22 sugar and flour mills operating on Gran Canaria by the early 1500's. Rodríguez Díaz (1988) identified 27 mills constructed over a 500-year period between the Barranco de Azuaje and the Barranco de Tenoya alone. The oldest of these mills tore through the forests in the *cumbre* and, in particular Montaña Doramas, so quickly that the crown restricted access to public forest lands in the 1520's (Pearson 1985).

Despite the large investments, sugar production was so lucrative that mill owners often repaid their formidable investment loans within 3 years. Silva (1961: 10007) estimates that the gross return rate for sugar production was 10 to 1 and the net return for the landowner was as high as 50% of their investments by the first decade of the 16th century. Not only did they profit on the milling and sale of their own crops, they charged large fees paid in sugar to farmers who did not own mills (Silva 1961, Quirantes 1981; Fernández Armesto 1982). Their power over modest farmers was so great that they increased their prices beyond established norms. Farmers responded by circulating a petition to the Crown in 1497 to complain that mill owners were violating a custom established during the first years of the colony in which farmers paid them half of the sugar they processed. Small sugar producers received royal permission to build their own sugar mill in Las Palmas in 1503 (Fernández Armesto

1982: 91). But the cooperative venture between the small farmers was not enough to guarantee them large profits because Genovese merchants who transported sugar to European markets dominated the local market.

Just as happens in many mono-cropping societies today, the sugar industry was profitable enough to reduce the production of subsistence crops so inhabitants had to import food. By 1508, sugar accounted for 43% of the merchandise exchanged on the islands, while cereals constituted just 1.8% (Silva 1961:1005). The island's nearly uncontrollable population of rabbits aggravated its chronic wheat shortages by devouring whatever was cultivated. Rather than take land out of sugar production, increase wheat production, and decimate the rabbit population, landowners and merchants defied royal prohibitions by importing wheat and corn from the other islands. The danger of famine was so great that the crown reversed its policy against importing wheat and then promoted its trade within the archipelago. In addition, colonists prodded the crown into ordering foreigners who owned sugar mills to import corn to sustain their workers.

But these measures barely maintained the beleaguered population. Landless workers and struggling farmers searched for alternative food supplies or passage to the Americas. Threatened with the potential depopulation of Gran Canaria, the Crown issued an ineffective prohibition against emigration in 1574 (Hernández González 1995:21). Eager colonists bribed Captains or stowed away on the ships. The landless and peasants who remained on the island lived in constant danger of famine and epidemic.

The Insular Markets

The insular market united producers who directed their goods towards the international market and those who produced for the island's population. As I stated before, the colony was dependent on the export opportunities and suffered the boom/bust cycles normally found in peripheral areas

(Bergasa Perdomo and González Viétez 1968, Martín Ruiz 1985, 1986a,b, 1989, 1990; Pérez Marrero 1991). The internal market provided the stability the population needed to survive the economic depressions.

Export agriculture followed the international market. The sugar industry collapsed in the late 16th century because it could not compete with rain-fed sugar cane production in the Caribbean. The prolonged economic downturn fostered the increased production of a variety of American crops including potato. Many landowners produced grapes and made wine which they exported to colonial America, Spain, and England between the 1740's and 1830's. Although Tenerife dominated the grape production, and thus gained economic and political superiority over the archipelago, there was some limited production in the north central region on Gran Canaria. The fall of the Spanish Empire and rise of English and French colonies altered the trade routes to the Americas and contributed to another economic depression in the archipelago. The demand for natural dyes sparked a surge in the cultivation of nopal cactus between the 1840's and 1870's. The cactus was host to an insect called cochinilla which produced a deep red dye when dried and crushed. The expansion of nopal cultivation was cut short in the mid-1870's when German chemists began producing artificial dyes. The archipelago's economy was transformed in the 1880's by closer ties with English merchants and the growth of European demand for banana, tomato and potato.

The laboring population and subsistence farmers were supported by agriculture, fishing, and herding. Crops like corn, wheat, potatoes, vegetables, spices, dairy products, poultry, tobacco, meat, chicken and eggs, fish, and medicines were exchanged in the insular market. The livestock also provided traction, feces for fertilizer, and bone for utensils like knife handles. The grasses and vegetation that grew around water deposits, the forests, and the farms provided material for kindling, thatch, mats, and fertilizers. Craftspeople made beautiful cotton and woolen clothing, utilitarian ceramics, agricultural implements, and religious fetishes.

The two markets were united as farmers, craftspeople, and merchants traveled clearly marked *caminos reales* (royal roads) to market their produce throughout the island. In addition to large weekend markets at parochial churches, merchants went to commercial and fishing ports, urban centers, and stores located next to the *molinos* and *trapiches* which ground sugar and wheat into *gofio*. The road system and markets were effective enough that people in even the most remote areas could purchase imported foods, cloth and tools and export their own.

The growing agricultural economy caused the population to increase slowly. Gran Canaria's population grew from 22,000 in 1688 to 71,181 by 1850 (García and González 1988; Pascual Madoz [1849] 1986:70). If census and demographic estimates for Arucas, Firgas, Teror and Valleseco are correct, then about 11,417 people or 16% of the island's population lived in these municipalities as of 1850. Madoz reported 4,373 people lived Arucas and 1,106 in Firgas. If 2,172 people lived in Valleseco in 1847, as is estimated by its *ayuntamiento*, and if Pasucal Madoz's estimate that 5,938 people lived in both Teror and Valleseco, then Teror's own population of was about 3,766 (Libro n. 1 de actas de Valleseco, sesión 20-I-1847 quoted in Suárez Grimón 1992: 76: Pascual Madoz [1849] 1986: 70).

The population growth was by no means constant because the island's erratic precipitation patterns and exposure to international travelers caused frequent famines and epidemics which caused temporary increases in mortality and emigration rates (Martín Ruiz 1985). In the 19th century alone, there were at least 8 famines and epidemics of cholera, yellow fever, and the bubonic plague. Mortality rates in 1811, 1828, 1838, 1847, 1851, 1862, or 1890, reached crisis levels (defined as 32 deaths per 1,000). In some cases, such as in the famine of 1890, the deaths attributable to starvation surpassed natural deaths and those caused by disease (Martín Ruiz, 1985: 127). Whenever times got bad in the Canary Islands, residents fled to the Americas. Many of the Spanish colonies throughout the Americas were either partially or completely founded by people who either passed through or were born in the

Canary Islands (Hernández González 1995). The destinations of choice changed during over the centuries as did economic opportunities. During the 19th century nearly all of the emigrants from Valleseco, Teror, Firgas and Arucas went to Cuba (Martín Ruiz, 1985 396).

As the population expanded, peasants and landed families settled the highland valleys. The poorest carved out caves in the hillsides while those who were better off or who lived on relatively flat valley land built strong one and two-story houses with thick stone walls, high wooden ceilings, sloped thatch or ceramic ceilings, and shuttered windows. Unlike the chilly modern homes, the caves and houses were designed for the dynamic climate; they provided warmth during the rainy winters and refreshing cool shade in the hot summers. Most houses were located within 15 minutes walking distance of springs and acequias which provided fresh water.

The island's irregular rainfall pattern placed a premium on water storage so farmers used picks and *azadas* to excavate hundreds of subterranean deposits called *aljibes, estanques*, and *depositos subterráneos* depending on their size. Where they could not excavate, such as in the lowlands or near phonolitic deposits, they built stone and mortar tanks. Neighbors and family members often shared the costs of construction and access to the aljibes and tanks, if not the water itself. They used barrels, jars, and buckets to capture and store household water. They also bought, leased, rented, traded, and stole water. Whenever possible they collected and stored rainwater in the aljibes and filtered their drinking water through pillars of basaltic stone. Most people had *pozos negros*, or pits where in which they disposed of their own waste.

The expansion of highland agriculture and irrigation systems sparked conflicts between highland residents and members of coastal heredades. Of the 170 social conflicts recorded on Gran Canaria between 1718 and 1847, 17% were motivated by water disputes (Suárez Grimón 1988). Many of these were class-based disputes because they pitted groups who had and did not have the right to irrigate. Waterless farmers stole and usurped water rights, by claiming before public magistrates that their families had used the water source for as long as anyone could remember, that is *'desde tiempo inmoreal'*.

Colonial Class Structure

Arbelo García and Hernández González (1988) divide the society into elite and common classes. The elite consisted of the nobility, merchants, and agrarian bourgeoisie. The commoner class was composed of medianeros, jornaleros, and an eclectic category for those without steady work. I am modifying their scheme by placing small landowners with little or no water among the lower class because they lacked the key to wealth and power.

The nobility included landowners who produced, milled, and exported crops. The capital they accumulated through the production and sale of export crops helped the favored colonial landlords extend their holdings through out the Canary Islands and into the Americas while funding religious and artistic works. The Spanish Crown bestowed the ranks of count, duke, or marquis on a few families. The nobility practiced partible inheritance, traced their ancestry in clans, and filled the upper echelons of civil political, military and religious institutions with family members. While some noblemen lived on large estates, most were absentee landlords who lived in the large towns like Las Palmas, La Laguna or Santa Cruz, if not on the Spanish peninsula in other European countries.

The nobility's control over land resources is clear in Valleseco, Firgas and Arucas. A census completed in 1850 indicates that 17 absentee landlords controlled 698 fanegadas (450 ha.) of land equaling 20% of Valleseco's territory. The most important of these absentee landowners were the Count of Vega Grande and a religious sect called the Data del Pino which was subordinate to the Roman Catholic Church. Other prominent figures included Bartolomé González, Agustín Manrique, Antonio de la Rocha, and Ricardo Tolosa. The same pattern holds true in Firgas and Arucas; 61 large landholdings belonged to 5.7% of the those who paid farm and land taxes in Arucas in 1863. Fifteen of the landowners lived in Arucas, another 18 lived in Las Palmas, and the rest lived in Firgas, Moya, Gáldar, San Lorenzo and Guía (Pérez Marrero 1991: 49). The earliest nobility in Arucas included the Palenzuela, Ariñez, Siberio, Mújica, Cerón, de Vera, Lugo, Conde de Vega Grande, Manrique, Ossorio, and Lara lineages. The Cerón family controlled the huge estate below the Montaña Arucas from 1572 to 1859, when the family's last spinster died without heirs. Their descendants operated their farms as corporate units and became professionals, entrepreneurs, and politicians during the transition to a capitalist economy.

Although the merchant class ranked below the agrarian nobility, the two have always depended on each other. The merchant class grew as French, British, Irish, Spanish, German, and Italian immigrants transported Canary Island produce to Europe and the Americas. During the past twenty years, Hindu, Russian, Arab, and Korean merchants have made significant inroads into the archipelago's market. Some of the most prominent merchant class families, such as Bonny, Blandy, O'Shannahan, Leacock, Ponte, Gourie, Massieu, and Petit serve as examples. English merchants extended their interests to the Canary Islands during the late 18th century. The Irish followed a century later. Most recently, East Indian, Korean, African, and a host of European nationals have become merchants.

While many of the merchants represented mainland and foreign enterprises, most run family businesses and maintain their ties with extended family members elsewhere. Arbelo Garcia and Hernández González (1988) recognize two kinds of merchants. The first includes those solely dependent on commercial activities such as banking, shipping, and retail for their income. The second refers to those who expanded their activities into agriculture and industry. Not only did many of the merchant families own vast plantations and begin to acquire rights to water from the heredades, they spearheaded the quest to mine groundwater in the 20th century.

The nobility and merchants both relied on the rural bourgeoisie who worked as administrative professionals with mercantile and agriculture interests. The rural bourgeoisie utilized substantial portions of the income they earned from their legal, medical, administrative, and other activities to rent and purchase land. For example, the Mayorazgo in Arucas has almost always been administered by professionals, not its owners. Furthermore, many of the largest heredades have been administered by merchants, bankers, accountants, and lawyers. There are other cases in which individuals rented and/or administered farms and molinos throughout the archipelago for the absentee landowners. The rural bourgeoisie gained access to the elite by working within the colonial government and church, serving both the nobility and merchants, and earning rents from their own agricultural investments. Although the rural bourgeoisie may aid the nobility, they also battled with them over water rights, taxes, and local autonomy. Their power was especially evident in the highlands during the 19th century. As the highland population grew, members of the rural bourgeoisie pressed hardest for rights to spring water and encouraged farmers living in Valleseco and Firgas to succeed from Teror and Arucas.

The relationship between the nobility, merchant, and rural bourgeoisie classes has always been tense. They intermarried to a large extent and shared many of the same political and religious beliefs. But these matrimonial bonds were often strained. The nobility controlled the land, political offices, and military. The merchants regulated their access to foreign markets. But the rural bourgeoisie controlled the operation of their agrarian and non-agrarian businesses. The tensions became more visible during poor harvests, invasions, or weak international markets. Despite occasional problems, neither group could survive without the other.

The rest of the Canary Islanders during the age of surface water may be classified as commoners. *Arrendetarios* (renters) were similar to the rural bourgeoisie in the sense that they rented land. Those fortunate enough to secure permanent leases improved their chances, or their children's chances, of entering the rural bourgeoisie. Small land owners often rented parcels from absentee landowners to meet the demands of their family and market. Small-scale arrendentarios were in constant jeopardy of losing their crops because they lacked water and\or suffered the full brunt of poor market and merchant prices.

Medianeros were landless and waterless peasants who cultivated fields owned by absentee landowners. They usually made all of the capital investments and gave landowners a percentage of their harvests as rent. Medianeros rarely rose from their station because landowners or their administrators claimed the bulk of the harvest whenever the market was good. They were sometimes left with less than they needed to survive. The only family of medianeros I met cultivates land in the Finca de Ossorio which the Manrique de Lara family donated to the municipal government of Teror. It is now a tourist site and educational center.

The members of these three groups usually divided their time between agriculture and some kind of domestic craft production and/or paid labor. Jornaleros occupied the lowest strata of the class system. They worked on a temporary basis for wages paid either in money or in kind. Jornaleros were farm hands, carpenters, construction workers, stonemasons, tinkers, blacksmiths, potters, weavers, shoemakers, molineros, and acquieros. If they could not find work, their only options were to beg, steal, or emigrate.

Summary

I have argued that the general formation of the Canary Island society during the era of surface water production was a direct response to external markets and local techno-environmental conditions. This chapter presented an summary of the agro-ecological foundations of Canary Island society between the 15th and early 20th centuries. The Spanish Crown and settlers had to create a stable colony that could simultaneously serve as a commercial link to the Americas and produce export crops. The colonists took advantage of Old and New World crops and irrigation techniques to create a vertical spectrum of agricultural activities that were well suited to the island's climatic, topography, and hydro-geologic processes. Two markets developed as farmers pushed into the highlands during troughs in the coastal export-oriented agricultural market. The initial distribution of land and water rights created a highly stratified and conservative colonial society whose shape could be recognized well into the first half of the 20th century. Now, as I will explain in Chapter Three, water property regimes played a central role in the evolution of the colonial society.

CHAPTER 3
THE EVOLUTION OF WATER PROPERTY REGIMES DURING THE ERA OF SURFACE WATER

> The waters were the principle cause of the origin and development of the current population nuclei. The canals, handiwork of men, spread through all of the cultivable corners and made the birth of hamlets and villages possible, always when connected with water and a heredad (Rizkallal Santana, 1990: 49).[1]

Land and water property regimes were the linchpins connecting the insular environment, economy, demography, and social organization. This chapter describes and explains the evolution of the water property regimes as they responded to international market opportunities and the techno-environmental conditions that the islanders confronted for the 400 year period that the supply of water was limited to rainfall, surface runoff, and spring water. As is consistent with my general model, I argue that the formation of water property regimes during the repartimiento reflected the efforts of landed colonists and the crown to promote sugarcane production above all other productive activities (Quirantes 1981: 85). Afterwards, the water property regimes evolved in response to the chain of events caused by the rise and fall of external demand for Canary Island export crops.

The Formation of Colonial Water Property Regimes

The crown began distributing water and land rights in the repartimiento even before Gran Canaria had been subdued. Royal officials called *repartidores* measured land, fixed property boundaries, and administered concessions. They distributed property to colonists in accordance to the recipients' role in the campaigns and/or their social status; the leading conquistadores and their families received large grants along with noblemen. In exchange, recipients were to live on and cultivate their lands for five years, but most of the nobility were absentee landlords. Favored colonists, by definition, received irrigable soils (riego) while less fortunate colonists received lands that could not be irrigated (sequero). Land grants were measured according to *fanegada* or *suertas* which amounts to the area sowed to produce 1.58 bushels of wheat.

The historian Leopoldo de la Rosa (1981) amassed evidence of at least nine kinds of property regimes that evolved during the 15th and 16th centuries. The crown granted recipients land ownership with proprietary usufruct rights:

1. to small springs and ponds.
2. under the condition that recipients recognize the authorized use rights of local residents to take water for domestic uses and livestock.
3. to *sobras* (water not consumed by others) on the condition that the recipients build *abrevadores* (watering troughs) and *lavaderos* (washing boards) along canals for authorized users.
4. if recipients agreed to power a mill or grant *sobras* to industries.
5. on the condition that recipients permit local residents and industries to purchase water at reasonable rates. Sometimes water rights were contingent on irrigation requirements of specific crops such as sugarcane, and after its decline, grapes and vegetables.
6. to *aguas perdidas* (lost waters). The Crown transferred water rights from those who did not take full advantage of their resources and gave them to colonists who claimed they could use it them in a more effective manner.
7. to unincorporated settlements.
8. to civil organization like the Cabildos Insulares and ayuntamientos.
9. to the Church.

Early repartimiento records indicate that the *dominant* property regime in the earliest colonial period was one in which the state owned the water, granted proprietary rights to land owners growing sugar cane, and gave everybody rights as authorized users to water livestock and withdraw water for domestic and public uses. There are four lines of evidence to support this assertion. As de la Rosa's work suggests, the crown granted titles to land with adscripted water rights. The connection between these rights and sugar production are usually, but not always, implicit. There is at least one case in which the crown explicitly required property recipients to grow sugarcane (Quirantes 1981:97). In addition, early settlers received fairly large land grants in Aguimes, Telde, Las Palmas, Tenoya, the Vega de Arucas, Guía, Gáldar, and Agaete as early as 1485. All of these areas were immediately put into sugar cultivation and at least some of the included highland pasture and proprietary rights to water.

The second line of evidence concentrates on the multilateral nature of the property rights themselves. The crown gave landowners irrigation rights but permitted other colonists to take water as long as they did not use it to irrigate their own crops. These conditional property rights and the crown's prohibition against irrigating crops above 300 meters in altitude make sense only as measures to ensure a ready supply of water for the sugar plantations and mills. The herders and subsistence farmers in the cumbre and medianía were forced to rely on winter rains and the summer's *nublina*.

Third, the state also settled water disputes in ways that promoted sugar cultivation. The crown stripped water rights from landowners who could not prove they were using their water advantageously to cultivate sugar. The crown granted these *aguas perdidas* (lost waters) to others who made defensible arguments that they would do better. The Crown's grant of aguas perdidas in the Barranco de Arucas to a consortium that was quickly amassing rights to lost waters throughout the archipelago led to the island's first recorded case of murder; the son of a prominent landowner slew the leader of the consortium after he claimed lost water rights to a large portion of the waters they considered to be their own (Fernández Armesto 1982).

Heredades

Perhaps the most important aspect of the state's effort to design colonial property rights around sugar production was its involvement in the creation of water-users associations called *heredades* and *heredamientos* (Table 3-1). For now, let me define heredades as collections of landowners with proprietary rights to water. Heredamientos are collections of proprietors who divide water from one or a collection of water sources. Heredades often subsume smaller heredades as well as heredamientos. They are particularly fascinating because they expose how water property regimes inspired by Mediterranean traditions evolved in response to local ecological and sociocultural conditions. Most irrigators in the Mediterranean had proprietary rights to public waters flowing through a canal. Peninsular water organizations such as those in Valencia or Alicante received an aliquot portion of water depending on the amount of irrigable land they owned and presaged the formal legislation governing the Spanish comunidades de regantes which I will discuss later in this chapter (Glick 1970, 1995; Maas and Anderson 1978). The fees they paid for the operation and maintenance of the irrigation system were determined by the proportion of the water they used. Under no circumstances could either the irrigator or the water users community transfer their water rights independently of the land. Active members who were either elected or appointed as officials to oversee the water community's activities in accordance with its customary laws. Civil law usually became applicable only when the members of these irrigation communities could not settle their own disputes.

The heredades in the Canary Islands grew out of this tradition. The property regime that evolved was one in which the Crown owned the water and granted land with attendant proprietary rights to water administered by heredades and heredamientos. Heredades were initially groups of individual proprietors who collectively managed their individual rights to water. Heredamientos were collections of individuals who divided water within one common rotational distribution system called a *dula*. Heredades often subsumed smaller heredades and heredamientos.

Table 3-1: Characteristics of Property Rights and Institutions Appropriating Water Between 1483 and 1920's

Institutions	Dates	Source of Water	Principal Technology	Location and Principal Uses	Property Status of Users
Cabildo Insular Ayuntamientos	1483-	Springs, surface runoff reservoirs		Public and household consumption throughout island.	Insular and municipal managerial control over state owned water and distribution systems. Firgas separates from Arucas and Valleseco separates from Teror in 19th century. They are obliged to protect public access to water, claim some water, but rely on heredades for water.
Heredad	1480-1866	Springs, surface runoff	Tomadores (Diversion walls) Madres Acequias (canals) Estanques (water tanks)	Coast. Sugar (1500's), Grape (1700's-1800's), Cochinilla	State owns most water. Colonists receive private ownership rights to land with attendant proprietary usufruct rights to water for irrigation. Crown grants some individual ownership rights to water separate from land. Illegal highland heredades formed during 18th century. All residents hold authorized usufruct rights for domestic purposes and livestock.
				Highlands. Expansion of irrigation for corn, potato, fruits, livestock	
Heredad	1866-1900's	Springs, surface runoff, Dams (1909-) Groundwater mining	Tomadores Madres Acequias Tunnels Tanks	Coast: Nopal Cactus (mid-1800's), Banana and tomato (1880's onward)	Water becomes alienable from land. Citizens may hold ownership or proprietary usufruct rights. Highland heredades formally given proprietary usufruct rights to state water. Water increasingly treated as private. Water law of 1866 declares subterranean waters reg nullis until owned by who ever brings it to the surface
				Highlands: Expansion of irrigation. Corn, potato, fruits, livestock	
Comunidades de Regantes	1887-	Springs and surface runoff	Tomadores Acequias Tanks Presas	Coastal consumption Banana, tomato, and subsistence crops	De Jure private proprietary usufruct rights to state owned spring and surface waters. Several Heredades become Comunidades de Regantes to protect water sources

As members of heredades and heredamientos, proprietors pooled their capital, but not their individual rights to water. Members could allocate their water as they saw fit; they could use, store, trade, rent, give, or sell water as long as it remained within the area the heredad served. In keeping with the principal of the primacy of individual land and water rights, the members were co-owners of indivisible real property, such as *madres* and *tomadores* (diversion walls) *albercones* (water deposits), *acequias* (canals), and buildings. One of the structural consequences of the jealously protected individual proprietary rights was that heredades were not independent jural entities, they did not legally exist apart from their members despite the fact that the membership established customary laws, elected officers, made decisions by voting, collected fees, invested in capital and labor, distributed water, and settled internal conflicts. The state appointed officials with jural powers whom were either elected or nominated by the members of heredades to oversee normal operations, enforce norms, and to render and enforce legally binding decisions concerning conflicts.

Like irrigation societies elsewhere, heredades evolved in response to the need to build and operate canal systems and clarify water rights in a way that emphasized flexibility Landowners had to build stone and earthen walls called *tomadoras* to divert water from the highland valleys into stone, dirt and wooden canals and carry it across public and private lands to their fields. To complicate matters, they had to refine their water rights because many of the repartimiento grants referred to 'as much land as can be irrigated' or 'as much water as can be used to irrigate' The grants usually did not specify either the source or amount of water a property holder could claim Instead, they gave the land owners rights to proportional amounts of the *gruesa* (undivided flow of a body of water) administered by the heredad operating in the region. As such, specific water sources were not directly tied to particular fields and anybody transferring land had to transfer a proportional amount of their water rights with it. As Glick (1972) points out, there seems to be a relationship between the amount of land and water distributed; property transfers in Firgas and Arucas during the 1520's shows that the transfer of one *suerte* or six *fanegadas* of land was accompanied by rights to five hours of water from the heredad providing water to the region.

Conflicts over water rights within the emerging heredades forced the crown to send its representative, Don Juan Ortiz de Zárate, to finish the repartimiento. Ortiz de Zárate arrived in 1506 and spent the next 25 years confirming, annulling, modifying, and establishing land and water rights throughout the archipelago. One of the earliest and clearest examples of the kind of situation that early colonists confronted pertains to Zárate's work with the Heredad de Tenoya in 1507 As he explains it, the members were facing difficulties because,

> the land of the said valley is very dry and overworked... At most it has to be irrigated once every twenty days and for shorter periods at a time, if the terms on which the water is shared will permit, because at the height of the summer, when need of the said lands is greatest, there is insufficient water for more than the said twenty-four allotments (Quoted in Fernández Armesto 1982:103).

The heredad appropriated water flowing from Cuevecillas, Madrelagua, Teror, and Tenoya The herederos seem to have divided the into 24 units, which probably corresponds to the hours of a day Despite the wealth of the water from these springs, there was still not enough during the height of the summer drought so Ortiz established loose rotational cycles called dulas and left the members of the Heredad de Tenoya experiment and modify them. Ortiz followed the same procedure elsewhere

The dulas formed by the heredades operated in a different manner than the Islamic and Hispanic irrigation associations which inspired them. The term *adulamiento* refers to rights to water within the cycle itself. The individuals holding the rights are *adulados*. In water-rich areas through out the mediterranean, adulados took as much as they could use before diverting the water to the person who owned the farm taking water from the next distribution point either away from or towards the head of the canal system. In areas suffering more extreme water scarcity, the amount of water distributed during each turn in the dula was more precisely defined by units of time and volume

Unlike the Islamic and Iberian water users associations, the heredades in the Canary Islands devised *dulas* that did not *necessarily* rotate up or down the distribution points in the canals. They commonly distributed water simultaneously to members whose farms could be located anywhere along their canal systems. Large heredades favored this system over the rotational system because the members normally cultivated a variety of crops on several parcels located in different ecological niches and needed to irrigate at intervals that were shorter than the dulas themselves. Farmers occasionally received water over a period of several days or on separate days interspersed in the dula. As such, a farmer's spot in the dula did not depend on the location of his or her farm. It did not determine where or when they could irrigate.

The majority of the smaller heredades that formed in the highlands during the 18th and 19th centuries had fewer members than the early coastal heredades which formed their initial dula by distributing water according to the proximity of the farm to the spring. They could distribute water following schedules that more closely approximated their irrigation cycles. Even so, one's position in the dula did not necessarily determine which plot would be irrigated or the point along the canal where the water was to be released. Most of the farmers in the small highland valleys were members of the same extended families. They frequently exchanged, rented, or share-cropped land in different micro-climatic regions without transferring their water rights. Therefore, farmers would irrigate various parcels of land whenever they got water according to the dula.

Of course, this does not mean that no heredades used a rotational sequence or that up-down canal disputes didn't occur. They did. For example, the Heredad de San Andrés captured water from springs in the Barranco del Azuaje and irrigated the highest farms before passing the remaining waters down to other heredades (Hernández Ramos 1954). Those who owned land farther away from the water source complained about not getting the amount of water due to them. In this instance, classic up and down canal disputes appeared between and within heredades. Nothing could be done to eliminate conveyance costs but local landowners could regulate the distribution of water more closely

Here, as elsewhere in the archipelago, the solution was to divide the valley into four parts that corresponded to the left and right banks and above and below 100 meters in altitude (Hernández Ramos 1954). The fertile lands surrounding the upland springs were irrigated according to strict dulas before the remaining water called *sobras* were divided into two parts and passed through the canals to irrigate the farms located in the lowlands.

Ordenanzas de Melgarejo

There is one more function that remained to be implemented before the heredades could operate autonomously. They needed judicial power. Towards the end of Zárate's career, a legal advocate in Las Palmas, Francisco Ruiz de Melgarejo, issued the famous Oredenanzas de Melgarejo in 1529 to establish some basic tenets of water management. The Oredenanzas were promulgated by the Real Audiencia in 1531 so the colonial judicial system could free itself from hundreds of minor disputes (Cabrera Hidalgo 1970; Glick 1972). The Ordenanzas created the *alcaldes de aguas* (water judges) to provide the heredades and non-members with publically recognized officials who could wield explicitly defined political and judicial powers. The alcaldes de aguas were appointed by the *Cabildo* for six month terms but the individuals themselves were usually members of heredades who were nominated and/or elected by their associates. The alcaldes de aguas presided over, guided, and acted as judicial authorities for the heredades. They heard disputes, rendered decisions, imposed penalties, and executed their sentences in conformity with the Ordenanzas and the customs of the heredades themselves. Alcaldes de aguas had to ensure that: the *acequieros* (canal workers) and *repartidores* (water dividers) kept the acequias clean and in working condition; that nobody either stole somebody else's water or was given water he or she did not wish to use or sell, the canals be constructed so that residents could take a reasonable amount of drinking and cleaning water for themselves and their animals; employees be paid; and all judgements be rendered without personal interest and in the effort to discern the truth. The alcaldes de aguas brought disputes before the Cabildo, Audiencia, and ultimately, the Crown itself if they were important enough. The Ordenanzas became the fundamental legal instrument governing water management for over 300 years. It gave heredades the political authority they needed to operate as self-governing water-users groups and established practices and property rights that many protect even today. However useful, the Ordenanzas could not prevent endemic water conflicts once farmers extended their reach into the highlands after the sugar industry crumbled.

Surveys of Heredades, Heredamientos, and Herederos in North Central Gran Canaria

I estimate that at least 60 heredades or heredamientos formed in the valleys running through Valleseco, Firgas, and Arucas during the age of surface water. It is fairly clear that the largest heredades formed in the early 1500's and were recognized in royal decrees. They captured water in the highlands and irrigated the coast lands at the mouth of the valleys (Figure 3-1). The Heredad de Tenoya captured water from the area below Cuevacillas and Madrelagua through Teror and the Barranco de Tenoya. The water irrigated land from Casas Ayala through the Barranco de Tenoya. The Acequia del Pinillo (now the Heredad del Pinillo y la Pila) appropriated water from springs in Teror near the Pico de Osorio and irrigated the region surrounding Montaña Cardones and Transmontaña. The Heredad de Arucas y Firgas (or as it was known in 1505 the Heredamientos de Firgas) captured water in the Barranco Dorramas (Barranco de la Virgen) to irrigate the entire area between the Barranco de Arucas and Casablanca. The Acequia de la Madre de Padilla (Heredad de San Andrés) irrigated the valley of San Andrés. The Acequia del Señor San Juan de Bautista irrigated land in both Arucas and Firgas. Most of the other heredades appeared as irrigation agriculture extended into the highlands and the descendants of land and water owners divided their inheritances. As I will explain later in this chapter, 23 (21%) heredamientos were created in Teror and Valleseco during the 17th and

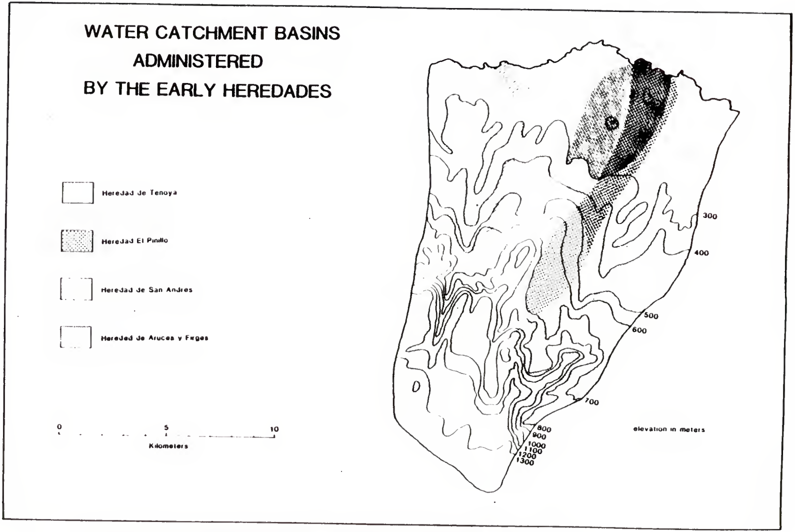


Figure 3-1 Areas Controlled by the Heredades During the 15th and 16th Centuries

18th centuries (Table 3-2). In 1850, Dr. Domingo Déniz found that of the 140 heredamientos operating on Gran Canaria, 29 were located within the confines of modern day Arucas, Firgas, Teror, and Valleseco (Table 3-3). In 1937 (Table 3-4), the ayuntamiento of Valleseco alone reported 45 named or unnamed heredades and heredamientos, 17 groups of herederos, and 16 individuals with rights to at least one of the 134 springs in its jurisdiction (Ayuntamiento de Valleseco exp 21(30) 1937) Some who had no springs collected runoff water and/or operated tanks (Table 3-5).

Evolution of the Heredades

The central premise of my thesis is that the property regimes evolved in accordance with shifts in the international market economy and local techno-environmental conditions. The fact that the sources of water did not change between the 16th and 20th centuries does not mean that the distribution of property rights or the constitution and practices established by the heredades remained static. The heredades, their property holdings, and water management practices were modified.

The information available about each of the heredades reflects, in large part, class differences in literacy and property interests that encouraged them to either adopts literate or oral traditions. The largest heredades had every reason to keep detailed records. They could establish and maintain records of fees, transactions, water measures, decisions, and activities. Record keeping became so important that the Crown and/or Audiencia occasionally commanded heredades to prevent disputes by recording its transactions. However, the state had little power or interest to enforce its decisions at such a local level. Indeed, the Heredad de Arucas y Firgas did not begin keeping its own running accounts until 15 years after being ordered to do so by the Audiencia in the early 18th century. In most cases, record keeping was possible only because the most powerful members of the heredades were wealthy and literate individuals who could hire professional scribes and scrutinize the accounts. Thus, they relied on written documents (and occasionally maps) to protect themselves from external challenges and

Table 3-2 Heredamientos that Formed in Teror and Valleseco in 1739

Heredamiento	Number of Claimants	Days in Dula
Cuevecillas	6	12
Madre del Agua	6	15
Rosadas	23	21
Agua del Borbollón de Francisco Báez	5	18
Acequia de las Peñas	8	23
Acequia Ultima	5	13
Acequia del Molino de Arriba	4	none
Acequia del Molino de Abajo	3	none
Barranco del Castaño	9	24
Agua del Borbollón de las Capellanías	5	15
Acequia Principal de Los Llanos	69	29
Agua de San Isidro	6	11
Agua del Chorro de Vega	3	5
Agua de las Matas	1	none
Agua del Chorro de Vega Hacia Abajo	6	12
Agua que va al Corredor de la de Montero	10	14
Agua de Juan Rivero	2	none
Acequia de Montero	9	14
Acequia de la Cuevecillas	13	18
Acquia de las Tuneras	15	20
Acequia de Juan Francisco	7	7.5
Acequia del Molino de Arriba	4	10
Desague de Dicha Acequia (Molino de Arriba)	2	none

Table 3-3. Heredades in Arucas, Firgas, Teror, and Valleseco Recorded by Doctor Deniz in 1857

Municipality	Heredamiento	Water Production Azadas/Day	M^3	Days in Dula
Arucas	Padilla	8	3,728	31
Arucas	Pinillo	1	466	46
Arucas y Firgas	Arucas y Firgas	8	3,728	31
Teror	La Madrecilla	0.25	116	22
Teror	Los Llanos	1.5	699	31
Teror	Enmedio	0.25	116	22
Teror	Chorrito	0.25	116	15
Teror	Molino de Enmedio	0.25	116	11
Teror	Montero	0.25	116	15.5
Teror	Corredor	0.125	58	17
Teror	Ojero	0.5	233	19
Teror	Enmedio, en los Arbejales	0.25	116	19
Teror	Alamo	0.66	307	22
Teror	Monteverde	0.166	77	10
Teror	Muñigal	0.166	77	9
Valleseco	Las Hayas			19
Valleseco	Barranco Oscuro	0.25	116	18
Valleseco	Molino de Tanque Abajo	0.75	349	20
Valleseco	Molino del Tanque Arriba	0.75	349	17
Valleseco	Risco Quito del Corralete	0.5	233	19
Valleseco	Risco Caido	0.5	233	16
Valleseco	Los Hijos	0.25	116	16
Valleseco	Cueva de Mena	0.5	233	8
Valleseco	Pinillo	0.5	233	
Valleseco	Andén	0.25	116	12
Valleseco	Sauco	0.25	116	9
Valleseco	Viñatigo			
Valleseco	Risco Gordo	0.125	58	13
Valleseco y Teror	Madres del Agua y Rosada			

Table 3-4 Organizations Claiming Ownership or Proprietary Control Over Water Resources in Valleseco in 1937

Case	Property Holder	Place	Production Rate (l/sec)	Days in Dula	Name of Source
1	Agustín Rodriquez Suarez	Valsendero	0.001		El Caiderillo
2	Alejandro Sánchez Diaz y otros	Valsendero	0.625		Los Gorillos
3	Alejandro Sánchez y Hermanos	Valsendero	0.008		Tanquillo del Risco
4	Andres Suárez y otros	Valsendero	0.001		Tranquillo
5	Ayuntamiento de Valleseco	Barranquillo	0.001		El Lomito
5	“ ”	Barranquillo	0.001		Fuente del Barranquillo
5	“ ”	Barranquillo	0.003		Fuente de los Pajeros
5	“ ”	Barranquillo	0.003		Fuente del Convento
5	“ ”	Barranquillo	0.004		Fuente de los Nogales
5	“ ”	Barranquillo	0.004		Tanquelera
5	“ ”	Barranquillo	0.005		Fuente del Laurel
5	“ ”	Barranquillo	0.22		El Prado
5	“ ”	Carpinteras	0.01		Fuente del ????
5	“ ”	Carpinteras	0.02		Fuente del Chorrito
5	“ ”	Carpinteras	0.02		Fuente del Pilon
5	“ ”	Caserón	0.001		Fuente de Caudillo
5	“ ”	Caserón	0.001		Fuente de Las Posas
5	“ ”	Caserón	0.001		Fuente de la Casilla
5	“ ”	Caserón	0.004		Fuente de las Casas
5	“ ”	Lanzarote			Risco Gordo, El Chorrito
5	“ ”	Lanzarote	0.001		Fuente de los Sánchez
5	“ ”	Lanzarote	0.002		Fuente de Lanzarote
5	“ ”	Lanzarote	0.002		Fuente la Laja
5	“ ”	Monagas	0.003		Fuente del ????
5	“ ”	Recinto	0.001		El Risco
5	“ ”	Recinto	0.014		La Rosa
5	“ ”	Troyanas	0.005		Fuente La Higuera
5	“ ”	Troyanas	0.01		Fuente de Las Troyanas
5	“ ”	Valsendero	0.005		Fuente de Cercado
5	“ ”	Valsendero	0.01		Fuente del Caidero
5	“ ”	Valsendero	0.017		Fuente de Los Hijos
5	“ ”	Valsendero	0.017		Fuente de Valsendero
5	“ ”	Valsendero	0.017		Fuente de la Mina del Barranco
5	“ ”	Zamora	0.003		Fuente del Sobradillo
5	“ ”	Zamora	0.004		Fuente de Cárdenas
5	“ ”	Zamora	0.015		Fuente de Zamora
5	“ ”	Zumacal	0.004		Fuente del ?????
5	“ ”	Zumacal	0.005		Fuente de la Barrilla

Table 3-4 Organizations Claiming Ownership or Proprietary Control Over Water Resources in Valleseco in 1937

Case	Property Holder	Place	Production Rate (l/sec)	Days in Dula	Name of Source
5	" "	Zumacal	0.01		Fuente del Chorrito
5	" "	Zumacal	0.01		La Tosquilla
6	Bartolomé Navarro y otros	Carpinteras	0.001		Chorrito
7	Bartolomé Rodríguez	Barranquillo	0.01		Casas Viejas
8	Carmen Fernández del Campo y otros	Barranco	3	18	Barranco Oscuro
8	Carmen Fernández del Campo y otros	Barranco	18	18	Molino
9	Carmen Ramos y otros	Madrelagua	0.001		Los Charquillos
10	Dolores Guerra y otroos	Valsendero	0.005		Chorro
11	Doña Jesús Díaz Guerra	Valsendero	0.002		Hoya de Moián
12	Evaristo Arencibia Rodríguez	Barranquillo	0.007		Vereda del Palo
13	Fermina Rodríguez y otros	Zumacal	0.003		El Chiquerete
14	Francisco Acosta Suárez y otros	Valsendero	4.02	0.07	Cueva de Mina
15	Francisco Deníz y otros	Madrelagua	0.003		La Huertenilla
16	Francisco Granado Cárdenas	Barranquillo	0.006		Barranquillo
17	Francisco Hernández Arencibia	Carpinteras	0.001		Los Andenes
18	Heredad de Arucas y Firgas	Barranco	48		Las Madres
18	Heredad de Arucas y Firgas	Monagas	1.5		Rapador
18	" "	Valsendero	1.32		Chorro del Grande
18	" "	Valsendero	1.4		Finca del Sahugo
18	" "	Valsendero	2.5		Gauja Nueva
18	" "	Valsendero	2.7		Los Nogales
18	" "	Valsendero	2.75		Los Canalisos
18	" "	Valsendero	3		Anima del Barranco
18	" "	Valsendero	3		Galería del Andén
18	" "	Valsendero	3.5		Chorro del Peral
18	" "	Valsendero	5		Los Arboles y Galería de Crespo
18	" "	Valsendero	2.5		Sahugo
18	" "	Valsendero	2.25	13	Canal
18	Heredad de Arucas y Firgas and others	Valsendero	10	13	Caidero de Navarro
18	Heredad de Arucas y Firgas and others	Valsendero	10	13	Macho (Retamilla)
19	Heredamiento de Aguas de Tenoya	Madrelagua	1	16	La Madre-El Chorro de Ruano
20	Heredamiento de Caidero	Carpinteras	0.02		El Chorrito

Table 3-4. Organizations Claiming Ownership or Proprietary Control Over Water Resources in Valleseco in 1937

Case	Property Holder	Place	Production Rate (l/sec)	Days in Dula	Name of Source
21	Heredamiento Fuente de Zamora	Zamora	0.001		Fuente de Zamora
22	Heredamiento Fuente del Laurel	Barranquillo	0.005	10	Fuente del Laurel
23	Heredamiento de Fuente Blanca	Barranquillo	0.01	12	Fuente Blanca
24	Heredamiento de Los Llanos	Madrelagua	1	16	La Madre. El Chorro de Ruano
25	Heredamiento de Risgo Gordo	Madrelagua	1.75	13	Chorrito. Marianas. Los Gatos etc..
26	Heredamiento de Tanquelera	Barranquillo	0.008	12	Fuente del Tanquelera
27	Heredamiento de la Carnicería	Barranquillo	0.01		La Carnicería
28	Heredamiento de la Chorrera	Zumacal	0.01		La Chorrera
29	Heredamiento de la Mimbrera	Monagas	0.007		Las Mimbreras
30	Heredamiento de los Laureles	Monagas	0.007		Los Laureles
31	Heredamiento del Labadero	Monagas	0.23		Los Labaderos
32	Herederos de Adan del Castillo	Madrelagua	2.5		Romero
33	Herederos de Apolinaria Sánchez	Caserón	0.004		Los Baras
34	Herederos de Bartolomé Mateos	Caserón	0.01		Caserón
35	Herederos de Bartolomé Suárez	Valsendero	0.139		Los Castañeros
36	Herederos de Bme. Sarmiento	Carpinteras	0.005		Carpinteras
37	Herederos de Bme. Suàrez Herrera	Valsendero	0.01		Carralete
37	" "	Valsendero	0.01		Chorro de Cueva de Lana
37	" "	Valsendero	0.01		El Morro
37	" "	Valsendero	1.75		Cuevas de Luna
37	" "	Valsendero	2.75		Risco Río Bajo
37	" "	Valsendero	3		Los Hijos
37	" "	Valsendero	3		Risco Río Alto
38	Herederos de Cristóbal Manrique	Lanzarote	0.002		Las Yeguas
38	" "	Lanzarote	1		Fuente Fría
38	" "	Lanzarote	1.1		Barranquillo del Finca

Table 3-4: Organizations Claiming Ownership or Proprietary Control Over Water Resources in Valleseco in 1937

38 Herederos de Cristóbel Manrique	Lanzarote	1.5		Los Corrales
38 " "	Lanzarote	1.75		El Estanque
39 Herederos de Eugenia Sarmiento	Caserón	0.01		La Casilla
40 Herederos de Francisco Gourie	Barranco	1	18	Las Hoyas
41 Herederos de Juan Pérez y otros	Zumacal	0.007		Las Granas
42 Herederos de Juan Rivero García	Madrelagua	0.017		Hoya de las Ajos
43 Herederos de Juana Suárez Sanchez	Valsendero	0.01		Chorrito de la Virgen
44 Herederos de María Navarro Sánchez	Valsendero	0.001		Los Minaderos
45 Herederos de Susana del Castillo	Lanzarote	0.07		Chorrillos
45 " "	Lanzarote	0.15		Tanque Blanco Corcho
45 " "	Lanzarote	0.17		Peñones
45 " "	Lanzarote	0.23		Fuente Colemada
46 Herederos de Vicente Arencibia y otros	Zumacal	0.003		Los Carrascos
47 Herederos de Vicente Suárez	Madrelagua	1		Charquillos
48 Herederos de Vincente Rodríguez González	Carpinteras	0.001		La Pila
49 José Acosta Sáchez y otros	Valsendero	0.003		La Paredilla
50 José Arencibia Pérez y otros	Madrelagua	0.014		Los Borbullones
51 José Guerra Sánchez	Valsendero	0.001		Hoyeta de las Tabarbas
52 José Rodríguez Rodríguez y otros	Carpinteras	0.001		El Caidero
53 José Santana Expósito y otros	Madrelagua	0.017		Chorro de Las Morrinas
54 José Suárez y otros	Valsendero	0.01		Las Helecheros
55 José Vincente Acosta y otros	Valsendero	0.001		Cuesta del Laurel
56 Juan Alemán Domínguez	Carpinteras	0.005		Lomo del Corte
57 Juan Díaz Guerra	Valsendero	0.001		Las Cuevecillas Los Montes
57 Juan Díaz Guerra y otros	Barranco	2		La Gallega
57 Juan Díaz Guerra y otros	Valsendero	7		El Agujero
58 Juan Pablo Guerra Guerra y otros	Valsendero	0.007		La Gambuecilla

Table 3-4 Organizations Claiming Ownership or Proprietary Control Over Water Resources in Valleseco in 1937

Case	Property Holder	Place	Production Rate (l/sec)	Days in Dula	Name of Source
59	Juan Ramos Sánchez	Madrelagua	0.001		Estanque Los Risquetes
60	Juan Suárez González	Madrelagua	0.001		Encima del Nogal
61	Manuel Aguiar Acosta	Madrelagua	0.001		Estanques los Huartillos
61	Manuel Aguiar Acosta y otros	Madrelagua	0.001		Del Río
62	Manuel Navarro y otros	Madrelagua	0.017		Estanque Blanco
63	Rosa Quintara Rodriguez	Valsendero	0.03		Estanque Redondo
64	Santiago Luján Nuez	Monagas	0.008		Los Andenes
65	Santiago Sánchez y otros	Valsendero	0.001		Orilla de Carralete
66	Serafin Díaz Guerra y hermanos	Valsendero	0.02		Casadores
67	Serafin Rodríguez y otros	Madrelagua	1		Las Granías Veñatigo
68	Simon Lujan Guerra y otros	Valsendero	0.1		Barranco Retamilla
69	Vicente García Rivero y otros	Valsendero	0.05		La Hoyeta
69	Vicente García Rivero y otros	Valsendero	2		Los Raises
70	Vicente María Quintana y otros	Madrelagua	0.01		Los ????
71	Vicente Rivero y José Pérez	Valsendero	0.02		Hoyeta junto a Los Garcías
72	Vicente Sarmiento Rodríguez	Carpinteras	0.001		La Mina

Table 3-5. Heredades and Heredamientos in Valleseco as of 1944

Case	Name of the Source	Valley	Owner, Proprietor, or Administrator	Irrigation Zone	Dula		Water Sales	Observations
					Days	M^3		
1	La Canada	La Retamilla	Heredad de la Canada	Immediate area	14	10	no	Small Spring
2	El Chorro	La Retamilla	Heredamiento Estanque del Chorro	Immediate area	9	3	no	Spring
3	La Hoyeta	La Retamilla	Vicenta Rivero Guerra	Immediate area	9	6	no	Small Spring
4	Juan Segura	La Retamilla	Heredamiento de los Riveros	Immediate area	12	7	no	Tank holding 2m3 and small spring
5	4 remanentes sin nombre	Cueva Corcho	Hnos. del Castillo y del Castillo	Cueva Corcho			yes	Sales during winter. 1/4 L /sec in summer
6	La Hoyeta	La Retamilla	Vicente Rivero Guerra	Immediate area			no	Two small springs
7	La Higuerilla de Retamilla	La Retamilla	La Higuerilla de Retamilla	Surrounding farms	12	100	no	Two tanks that hold 10 and 5 cubic meters
8	Risco Gordo	Madrelagua	Cdad. de Regantes Risco Gordo	Madrelagua	12		no	1 l/sec in summer
9	El Viñatico	Madrelagua	El Viñatigo	Bordering lands	8		no	Galeria, spring and tank holding 400 m3, 900 m^3/yr.
10	Arriba de los Estanquillos	Madrelagua	Arriba de los Estanquillos	Bordering lands	8		no	Two tanks holding 10 and 190 m3, 200 m3/yr
11	Heredamiento de la Fuente de Zamora	Zamora	Hdmto. de la Fuente de Zamora	Land in Zamora	12		no	take water remaining after public consumption
12	Hto.del Estanque Chico del Barranquillo	Zamora	Hto. Estanque Chico Barranquillo de Zamora	Land in Zamora	12		no	Two springs in same valley
13	La Peña	Zumacal	Naciente de la Peña	Immediate area	15			Tank holding 4 m3 for remaining waters
14	Las Falconas	Zumacal		Zumacal	24			Dry spring and 10 m3 tank
15	El Chiquerete	Zumacal		Zumacal	19		no	Spring and 20 m3 tank

Table 3-5 Continued Heredades and Heredamientos in Valleseco as of 1944

Case	Name of the Source	Valley	Owner, Proprietor, or Administrator	Irrigation Zone	Dula Days	 M^3	Water Sales	Observations
16	El Moralillo	Zumacal	Juan M Rodríguez Pérez	Immediate area	13			Spring and 10 m3 tank
17	Estanque de la Fuente de las Perlas	Zumacal		Bordering farms	9	10	no	Rights to water remaining after public consumption
18	La Hoya	Zumacal		Immediate area	22			Dry spring and 3 m3 tank
19	Hdmto del Estanque Viejo de A Diaz	Zumacal		Bordering lands	24	5	no	not enough to irrigate 12 furrows
20	El Caidero	Carpinteras	Heredamiento del Caidero	Carpinteras	16	60	no	Spring and 8 m3 tank
21	Fuente del Junco	Carpinteras	De la Fuente del Junco	Bordering lands	16	10	no	Dry spring and tank to hold remaining waters
22	Estanque del Lomo del Corte	Carpinteras	Juan Alemán Dominguez y otros	Bordering lands	17	20	no	Tank fills every 10 days
23	El Cardoso-Estanque Grande	Troyanas	El Cardoso-Estanque Grande	Bordering lands	21	1500	no	Tank can hold 500 m3 but spring can produce 1500 m3
24	Hdmto del Cardoso-Hoya Nueva	Troyanas	Hdmto. del Cardoso en La Hoya Nueva	nearby lands	18	15	no	Barely useful due to drought
25	Barranco Oscuro	Barranco Oscuro	Marquesa de Arucas (2 parts) + Ponce Martín (1 part)	Barranco de la Virgen	30	2	no	part of the gruesa
26	Heredamiento de las Hayas	Barranco	Heredamiento de Las Hayas	Bordering lands	15	500	no	Two springs and tank holding 1500 m3
27	Molino	Barranco de La Virgen	El Molino	Barranco de La Virgen	17		no	Municipality of Arucas owns part; 2 2 l/sec
28	Risco Quio Bajo	Valsendero	Heredad del Barranco	Barranco de La Virgen	19	2	no	Spring
29	Las Helecheras	Valsendero	José Guerra Sánchez	Immediate area		720		One spring and two tanks holding 4 m3/yr

Table 3-5 Continued Heredades and Heredamientos in Valleseco as of 1944

Case	Name of the Source	Valley	Owner, Proprietor, or Administrator	Irrigation Zone	Dula		Water Sales	Observations
					Days	M^3		
30	El Chorro del B. de La Retamilla	Valsendero	El Chorro del Barranco Retamilla	nearby lands	8	200	no	Tank holds 40 m3
31	El Estanque del Río	Valsendero	El Estanque del Río	Boadering lands	16	30	no	Tank for the sobras to Sahugo
32	El Agujero	Valsendero	Heredamiento del Agujero	Valsendero	13	5	yes	Tank holds 350 m3, They sell some water daily
33	Riscoquío	Valsendero	Heredamiento de Riscoquío	Valsendero	16	1	yes	Sell part of water during winter
34	Cuevas de Lana	Valsendero	Heredamiento de Cueva Lana	Valsendero	16		no	Sell part of water during winter (amount unknown), 25%???
35	Los Hijos	Valsendero	Heredamiento de Los Hijos	Valsendero	16			Sell part of water during winter, not during summer 50%???
36	Cueva Mena	Valsendero	Heredamiento de Cueva Mena	Valsendero	15	225	no	Tank holds 100 m3

regulate their internal affairs. Thus, the best documented cases, including the Heredad de Arucas y Firgas and the Heredad de Tenoya, provide fairly clear evidence about the most important changes in the region. In contrast, many of the smaller heredades and heredamientos had neither the material nor human resources to keep written records. They were usually composed of small, related groups of illiterate farmers who worked together in an oral tradition of *uso y custumbre* (use and customs) which amounted to oral customary substantive and procedural law. Most of the written information about these heredades concerns land and water transfers, taxes, municipal hydraulic and agricultural surveys, formal legal disputes, and books about local history. The differences in legal traditions have affected water disputes through out the history of the Canary Islands, but, as I will discuss in Chapter Four, proved especially important from the 19th century onward.

In the following two sections, I explain how and why the Heredad de Arucas y Firgas and the Heredad de Tenoya evolved along divergent paths. The former consolidated its power over water resources in the highland. Its acequias and system of water measurements became the basis of the water management system during the 20th century. The latter lost most of its own water resources to highland farmers. The conflicts over land and water resources that embroiled both heredades were instrumental in the formation of many of the highland heredades, at least one comunidad de regantes, and all of the ayuntamientos in the area.

The Heredad de Arucas y Firgas

The Heredad de Arucas y Firgas is *the* quintessential heredad in the archipelago. Not only does its documentation provide us with a rare opportunity to examine the evolution of one heredad, its prominence makes it critical to understand water management in north central Gran Canaria.

The Heredad de Arucas y Firgas controlled the largest amount of land and water in the region, and thus became the region's most powerful local social institution. Its influence is still so pervasive that farmers throughout the area simply refer to it as "the heredad" Since its history is as long as it is complex, I will focus on its resources, administrative structure, and system for measuring and allocating water rather than descend into a labyrinth of historical detail

Acquisition of Land, Water and Technology

The history of the Heredad de Arucas y Firgas begins with the conquest itself It grew as landowners united three distinct heredamientos and the most powerful families in the Vega de Arucas Tomás de Palenzuela, the son of a conquistador, acquired the rights to an abandoned Canario settlement called Alfurgad (Firgas) immediately after the conquest. He received more land in Arehuc (Arucas) in 1493. Over the next twenty years, Palnezuela had jornaleros build a canal system made of earth, wood, and stone to carry water from his springs at Las Madres to his sugar plantation in Firgas. In 1505, the Crown recognized his canal system as the Heredamientos de Firgas By 1512, Palenzuela had extended his canal system into the Vega de Arucas. As the water flowed through a 12 km canal, it powered sugar mills in Firgas, La Goleta, Arucas, and Montaña Arucas, plus provided drinking and cleaning water throughout the area. The second heredamiento formed when Palenzuela's daughter married Juan de Ariñez, who had been the ex-personal secretary to Queen Juana before immigrating to Gran Canaria where he became the Escribano Mayo (Chief Record Keeper) of the island's Cabildo. The couple purchased more land in Telde and Arucas (Quevedo Rosales 1977; Riskallal Santana 1990; Fernandez Armesto 1982). Ariñez acquired rights to very productive springs in Valsendero which later bore his name. In 1522, they built an acequia called the Mayorazgo (literally, an entailment) parallel to Palenzuela's own acequia. The acequia transported water to the area currently irrigated by the Acequia Alta in Hoya de Ariñez and Transmontaña, Arucas The third heredamiento arose as the Timagada family, which may have been one of the few Canario families to acquire land and water property, built the acequia de San Juan de Bautista next to the other two canal systems to bring water from the San Juan springs in Firgas to Arucas Property rights to land irrigated with water from these distinct heredamientos began to shift as heirs bought and sold land. Capitán García de Osorio acquired some of Palenzuela's land from descendants to clear their debts. Pedro Cerón later purchased land from Osorio, Palenzuela, and Vera's descendants By 1577, Cerón and his wife Santa Gadea founded the Mayorazgo de Arucas, one of the two royal entailment, or untransferable estate, granted by the Crown in the Canary Islands. They produced sugar cane, wheat, grapes, and ordinary fruits on 324 ha. of land located in Arucas and another 146 ha. in Firgas. They were the proprietors of 240 azadas of water, some of which came from the Heredamientos in Firgas (Quevedo Rosales 1977: 6, Pérez Marrero 1991:43).

The heredad expanded its land and water property during the mid- 19th and 20th centuries. The increased cultivation of the highlands presented an initial challenge to the heredad. It could not risk allowing the development of a large waterless population in the Barranco de la Virgen that would only steal and usurp its own claims to water flowing through the valley. Fortunately, for the members of the heredad, the valley is very steep, and the cultivable land is generally located along the valley floor. As part of its quest for water, the heredad entered into tense unions with highland heredamientos such as the Heredamientos del Agujero, Sahugo, and El Molino. The first refers to a small group of farmers in the valley's principle settlement, Valsendero. The farmers held rights to a portion of the water flowing from a spring administered by the Heredad de Arucas y Firgas. After visually calculating the rate of flow from the spring, the Heredad de Arucas y Firgas and the Heredamientos del Agujero built a cantonera that had a circular hole near the bottom. Water flowing through the hole went to the Heredameinto del Agujero and the rest went to the coast. Other arrangements were made with the Heredamientos Sahugo and El Molino.

The heredad increased its control over the valley during the 1860's when the newly formed Republican state sold off estates held by nobility and the church. Since part of that property included the waters from the heredamientos San Juan and Mayorazgo, the members of the heredad who purchased these properties essentially bought rights to water the heredad already administered. The difference was that the water was now private property and alienable from land rights. Although water had been increasingly sold apart from land for years, this was the first time such a massive transfer received public and state support. With water from the Mayorazgo and San Juan owned by members who received water in the Heredameinto de Firgas, the need for three distinct, and redundant heredamientos disappeared so the heredad consolidated them all into one large heredamiento.

The heredad amassed even more land and water in Valleseco several years later. Don Bartolomé González Rodríguez purchased land and water rights in the Cortijo de Valsendero during the state auctions. He made a deal with the heredad to build an acequia from the Cortijo to the head of the principle canal at Las Madres in exchange for the right to transport his water to the Vega de Arucas. Several disagreements forced the heredad and Don Bartolomé to suspend the deal. He died before they could solve the dispute. His widow, Doña Joaquina de Matos, sold the members of the heredad her rights to all of the water in 1869. Since the heredad could not technically own anything, the membership received additional water in proportion with their previous shares.

The heredad purchased even more land in and around the Barranco de la Virgen during the 1920's because land rights carried with them mining rights which could be used to open groundwater mineshafts while blocking others who sought them. By the 1940's, the heredad controlled most of the land and waters between Los Moriscos and Las Madres. It had successfully consolidated its power over the rainiest area on the island.

Still, its members could always use more water. The rise in the banana market during the closing years of the 19th century lead the members of the heredad to revive plans it had made during the height of the cochinilla boom in the 1850's to build a large dam in the Barranco de Pinto. The dam was intended to capture winter runoff waters. The tremendous profits being amassed from banana cultivation made it possible for the heredad to construct the archipelago's first large scale dam (Pinto I) in 1909. It then constructed a second dam (Pinto II) in 1913. Together, these dams hold a combined total of 750,660 m^3 (Pérez Marreo 1991).

The Acequias

Since the heredad's membership stretched from Moya to Cardones, its system of *acequias* and *sub-acequias* (canals and secondary canals) became the basis for water distribution from the 18th century onwards. The expansion of irrigated agriculture into the highlands during the same period affected the heredad's access to construction supplies. The demand for land and wood for agriculture and building materials for structures like the acequias grew so intense by the late 17th century that the heredad pleaded with King Carlos IV in 1706 to prevent farmers from deforesting Montaña Doramas. The state owned the area but residents managed — and needed more arable land. The heredad argued that the deforestation of Montaña Doramas would decrease rainfall and make valuable timber even more scarce. That, in turn, would increase the price of maintaining the heredad's wooden acequias. The heredad's need for construction materials prompted its members to take stone, straw, and calcium from Montaña Doramas without state permission in 1713. The heredad was fined and did not repeat its error; in 1763, it asked the Audiencia's permission to fell trees in order to repair its acequias. The entire matter was resolved unilaterally by Ferdinand VII in the 1820's; he granted large tracts of Montaña Doramas to General Morales for his efforts to expel Napoleon's troops from Spanish soil. Morales deforested the mountain and his peasants began cultivating its soil.

Once the heredad could not rely on Montaña Doramas for cheap wood or more durable materials, it turned to alternative supplies. Quarrying Blue Phonolitic stone in Arucas, it took advantage of the situation to replace all of the wood and earthen acequias with large stone and mortar acequias over the next 170 years. The heredad took advantage of the material to solve structural problems as well as to deter water theft, which like the water market, grew with the intensification of agriculture in the lowland and its extension in the highland. The heredad destroyed all of the wooden acequias and exposed *paletas* (sluice gates) and built a new principle acequia made of mamposteria (stone and mortar) and distribution weirs called *cantoneras* at 18 strategic locations. As an added security measure, it housed all but the final cantonera inside small sturdy edifices called *cajas de aguas*. Standing about 4 by 3 by 3 meters, their thick stone and mortar walls, bolted wooden doors, and barred windows effectively prevented anybody from manipulating the cantoneras. The acequia begins at its tomadora at Las Madres (Figure 3-2). The canal stretches several miles and rounds Montaña Firgas where excess water can be diverted and stored in a long tunnel. The first cajas de aguas distributes water farmers in the Barranco de Azuaje and near the pueblo of Firgas before weaving its way through valleys to an albercón (water deposit) in a small horseshoe valley called Tomás de León. The heredad measures the volume of water it has to distribute at the albercón.

Water Measurement

The heredad used to estimate the volume of its water by *vista de ojo* (visual inspection) and estimated time by the relative position of the sun to the horizons. A day equaled the 12 hour period between sunrise and sunset when a person could see without the aid of artificial light. Nighttime lasted the other 12 hours. The heredades divided the gruesa according to various units of measures, including days, hours, and *azadas*. The term azada refers to the dimensions of the triangular hoe farmers use but as a measure of water, an azada was considered a portion of the gruesa. An azada could refer to the amount of water that flowed through the head of a canal or through a distribution point in 1 hour, 12 hours, or 2 days. An azada could be divided according to time units as well as proportional units such as a *cuarto* (1/ 4th azada) and *surco* (1/ 8th azada).

The heredad refined its water measurement techniques over the years. Today farmers in

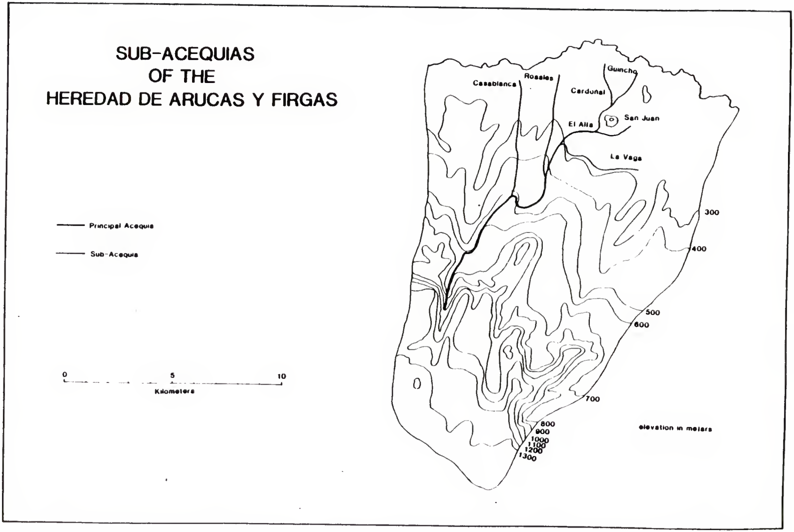


Figure 3-2. The Acequia and Sub-Acequias of the Heredad de Arucas y Firgas

Valleseco, Firgas, Arucas, and Teror tend to speak about "azadas de 60 mm o 25 mm.."[2] These measures are based on the architecture of the albercón and cantoneras. The heredad channels water from its sources into deposits in the highland and then sends it through canals to an albercón where the volume of water in the tank is calculated by counting the number of large bricks in the wall above the water line. Any farmer above the albercón receives his share of the *agua de hilo*, which is the amount of water that flows by gravity during 12 hours. Anybody below that point receives water measured according its volume without due regard to time. The reason for this is that the volume of water reaching the albercón can be distributed at rates determined partly by the volume of water in the tank, and the dimensions of the tank opening.

The key in regulating the amount and rate of water flow is the cantonera. Cantoneras are receptacles that often take the form of circles, squares, rectangles, triangles, and arches. Their most common shape is a Romanesque arch. There are two low walls located at the entrance. A cavity extends to the far end of the arch beyond them. The cavity's depth varies according to the volume of water its designers expected to distribute. Square or rectangular stone blocks are placed at proportional distances from each other on top of the sides of the cantonera. The space between the blocks on the sides of the cantoneras are bocas (mouths). Their number and sizes may differ from cantonera to cantonera, but must be proportional to the others within the same cantonera. The standard bocas at key distribution points are 183 millimeters thick, 200 millimeters in length, and 80 millimeters high.

An acequiero measures and regulates the volume of water passing through each boca by sliding a tablilla, a rectangular piece of wood 80 mm high and 200 mm in length and 10 mm wide, into a divot cut into both sides of the boca. He lifts the tablilla and passes or wedges slim piece of wood called a vitola underneath it to prevent the tablilla from moving. The vitolas are cut to various lengths depending on the amount of water to be distributed. Water flows in from the flat side of the cantonera. Since the surface of the water must be muerto (dead or calm) to measure the rate of flow, it passes under and/or over two walls, before entering the central cavity. Because the water enters rapidly, the bocas nearest to the entrance receive slightly less than those located in middle and far side of the cantonera. Circular and square cantoneras avoid this problem by forcing the water to rise in the center of the cavity and spill over containment walls before flowing into the main cavity and then the bocas Regardless of the shape of the cantonera, the water level rises to the upper rim of the tablilla as it passes through the bocas. Acequieros calculate the rate of water flow and, consequently, the volume expected to pass through the boca in a specified amount of time by knowing the dimensions of the boca and the distance between the base of the boca and the base of the tablilla. The Heredad de Arucas y Firgas published a conversion sheet which acequieros and vendors carry with them.

With Water, Two Plus Two Do Not Equal Four

Farmers and other people in Arucas today commonly refer to two kinds of azadas. An *azada grande* is the amount of water that passes for 12 hours through a boca that had a tablilla raised 60 mm. An *azada chica* is one in which the tablilla is raised to 25 mm. According to the heredad's conversion sheet, an azada of 60 mm equals 433.110 m^3 and passes through the boca at a rate of 10.03 l/sec. An azada equaling 201.75 m^3/12 hrs or 4.67 liters/sec requires that the tablilla be lifted 30 mm. The biggest azada that the heredad can distribute is an azada of 200 mm which equals 1,944 m^3/12 hrs or 45 liters/sec. Notice that an azada de 60 mm passes through a boca at a rate of 10.03 liters/sec while the azada de 30 mm passes at a rate of 4.67 liters/sec. Two times 4.47 equals 9.94 liters/sec, not 10.03 liters/sec. Why do they yield different values? Water flows out of a tank at rates determined by the dimensions of the tank, the outlet, the amount of water in the tank, and atmospheric pressure. The more water you have in the tank and the wider you open the tank's valve, the faster water flows out. Thus, more water flows out per unit of time. That is why "con agua, dos y dos no son cuatro" or, with water, two plus two do not equal four.

The cantonera's ingenious architecture and measuring system give acequieros some leeway. They keep track of the water they are distributing by adding and subtracting the amount of water that they divert in each cantonera as they travel from the uppermost part of their route to the lowest. Acequieros regulate water flows by partially opening and closing bocas. All of the cantoneras are equipped with standard bocas. Many have half-size and double sized bocas as well as stone or cement blocks that close off 1/3, 1/2, and 2/ 3rds of the standard boca. These devices give acequieros plenty of options. They can send an azada through one standard boca in 12 hours or use a double-sized boca to send it in six hrs. or they can open 2 double-sized bocas to send an azada in 3 hours. They can also send an azada in 9 hours by using one standard sized boca and 2/3 rds of another. Conversely, they can send 6 hours of water (1/2 azada) in 9 hours by blocking off 1/3 of a standard boca. No matter how skilled the acequieros were, they spent the day running back and forth between cantoneras and tanks to regulate the rate and direction of water flow.

The heredad's dula, cantoneras, and system of measuring water became standards through out the region. Even though the heredad's way of measuring water was fairly effective, its success within the dula system was partially dependent on the measurement of time. Discrepancies in time keeping created incessant conflicts. The heredad went a long way to solve the disputes in 1851 by installing a large clock on the church steeple in Arucas where everyone in the Vega could either see or hear one common measure of time. While the citizens of Arucas erected the Iglesia de San Juan on the spot of the earlier church in 1909, the heredad mounted the clock on iron girders to keep it in operation. More recently, limnigraphic and volumetric gauges make water measurement even more precise.

The Dula:

By the time the sugar industry collapsed in the late 16th century, the heredad included the Firgas, Mayorazgo, and San Juan heredamientos. The heredad established a dula 31 days long. Each day was divided into ten-hour day and night-time periods. The water itself was divided into aliquot shares based on hours or *unidades* (units). In 1695, conflicts about who owned the nighttime water of the 31st day in the dula forced the herederos to seek outside council. It solved the conflict over the disputed water by setting them aside to be sold as *sobras* to cover the heredades' expenses. In 1739, the heredad instituted a 31 day dula, and divided the *gruesa* into 24 units; each unit equaled one hour or one azada. As such, the heredad allocated 744 azadas in each dula. The Heredamientos of Firgas and Arucas had 409 azadas. Another 209 went to the Mayorazgo. San Juan kept 93. The remaining 33 azadas were set aside to be sold; aside from the 2 azadas it sold as sobras, the heredad added 31 azadas in the remaining portion of water called the *secuestro*.

The addition of the Pinto I and II posed an interesting problem because their water sources were governed under the laws passed by the Republican Government. The heredad sequestered an additional azada of water from the herederos to raise the necessary capital. The water was public, but the members of the heredad acquired proprietary rights. The dams constituted their own heredamientos. The heredad now divides the water from the 2 dams among all the herederos during the summer. It calculates the amount of water each heredero can receive by estimating the amount of water in the dams, subtracts the volume lost to infiltration and evapotranspiration, and divides it by the portion of water that each heredero owns in the regular heredamiento (Heredad de Arucas y Firgas 1923).

The location of the dams and their status as a separate heredamiento caused two allocation problems. Since the dams were located in the Barranco del Pinto, the water could only be distributed to the herederos who acquired their water from cantoneras at or near the dam or from the sub-acequias El Alta and the San Juan. Those getting their water from the main canal or the Rosales, Casablanca, or Vega sub-acequias could not receive any. The heredad compensated these herederos by increasing the amount they received during in the regular heredamientos. Secondly, the heredad built a separate system of cantoneras and acequias to carry the water to the sub-acequias.

The Emergence of a Water Market:

The Canary Islands is among one of the few places in the world where a regular water market arose in an agrarian area that relied on gravity flow irrigation. The market demand for wine and subsistence crops during the 17th and 18th centuries sparked a resurgence in demand for water along the coast just as highland farmers expanded their subsistence production into the medianía Most of the farmers eventually increased their production to the point where they could no longer acquire enough water from their own heredades. Farmers connected sub-acequias operated by neighboring heredades and began trading, borrowing, renting, and selling water. The growing demand for water and the market reinforced a long trend in the complete transfer of ownership from the state to private individuals.

The history of the Heredad de Arucas y Firgas makes it clear that the market developed despite repeated legal attempts to block it. As of 1647, farmers throughout the Vega de Arucas were legally entitled to take water from the Heredad de Arucas y Firgas while those in Cardones took water from the Heredad del Pinillo. By 1700, members of the Heredad de Arucas y Firgas began to sell water to farmers in Cardones. They transferred water from the Acequia Real to the sub-acequia del San Juan, and from there through the Acequia de Los Guirres in the Barranco de Arucas to the sub-acequia of the Heredad del Pinillo. Some members of the Heredad de Arucas y Firgas demanded that farmers in Cardones irrigate with water from the Heredad del Pinillo. The Audiencia did not object to the water transfers and secret transfers continued in spite of legal attempts in 1704, 1786, and 1839 to block them. The heredad reluctantly legitimated inter-basin transfers in 1840. From that moment on, all of the farmers could acquire water from any heredad that could send water to them.

Distribution of Property and Institutional Structure

The size, composition, and thus, the distribution of power in the heredad has become more diffuse since its inception. As I mentioned before, the heredad was created as a result of marriage alliances among colonial families. The number of members grew as landowners distributed partible inheritances among their children who often sold their lands. The inheritance practices ensured that most of the extended families in the lower reaches of Firgas and Arucas held rights to water administered by the heredad. By 1710, there were at least 65 individuals or families with proprietary rights to water in the heredamientos (Quevedo Rosales 1977: 16). The Marquis of the Mayorazgo claimed 209 or 33% of the Heredad's 620 hours of water. Doña Luisa Trujillo claimed another 148 (23%). Together they controlled 57% of the Heredad's water. Ten others enjoyed between 6 and 16 hours (16%) of the water. The rest received less than 5 hours and together controlled about 26% of the total amount. Most had very little water and searched for ways to get more.

The effect of land tenure, sales, and partible inheritance patterns across the centuries clearly effected the distribution of water rights within the heredad. The number of members grew more quickly following the 18th century as the population grew and land was divided through inheritances and sales. Even so, the distribution of water rights remained closely associated with land ownership. In 1810, the heredad had 350 members. As of 1938, it had 651 members (Table 3-5). Almost 80% claimed less than 1 azada during each dula, and 97% less than 6 azadas. Less than 3% of the owners received 43% of the water during every dula. Almost all of the members who owned more than 20 azadas came from 2 extended families. In 1986, the heredad claimed 750 members. The owners of the Mayorazgo owned 6.8% of the water. The 22 members who own more than 6 to 10 azadas owned 39.5% of the water. The rest of the members do not have enough water to irrigate even one fanegada, and therefore, must acquire it somewhere else. In fact, 60% lay claim to less than one hour's worth of water and 20% are adamant about holding on to their rights to less than 15 minutes. In 1995, the heredad claimed over one thousand members and had at least several members who owned rights to less than a minutes worth of water.

Table 3-5 Property Distribution Within the Heredad de Arucas y Firgas in 1938 and 1986.

	1938		1986	
Amount of Water	Number of Members	Percentage of Membership	Number of Members	Percentage of Membership
<1 azada	515	79.8	610	81.5
1-6	113	17.3	118	15.7
6-10	11	1.6	12	1.6
10-20	6	0.9	7	0.9
20-40	5	0.7	2	0.2
40+	1	0.1	1	0.1
Total	651	100	750	100

Source: Pérez Marero (1987, 1988)

The growing membership combined with opportunities to implement sociolegal changes instituted at the national level forced the heredad to modify its administrative and voting procedures. The first major change was the abolition of the office of alcalde de aguas in 1839. Its downfall was caused by two interlocked changes. The first factor was the extension of small scale agriculture into the mediania and highlands of Firgas. The farmers in Firgas tried to gain greater control over local affairs and the water administered by the heredad. They formed their own ayuntamiento when the Spanish republican government made its sweeping constitutional reforms between 1812 and 1836. The Constitution of 1812 provided residents of Firgas with a way to boost their control over the water flowing past their fields. Meanwhile, Arucas formed an ayuntamiento meant to control entire Vega de Arucas. Since alcaldes de aguas were assigned to municipios because they were civil jurisdictions, and the Vega de Arucas had been divided into Firgas and Arucas, both factions named two alcaldes de aguas. The heredad appealed to the Audiencia and jefe político de la provincia (the gobernador civil). The heredad's legal advisor argued that Firgas could not nominate 2 alcaldes de aguas because Firgas had not been founded legally, the meetings of the heredad were always held in Arucas, and most of the members irrigated land in Arucas, not Firgas. The jefe político examined the Oredenanzas de Melgarejo and ruled that the police duties of the alcalde de aguas would be transferred to new officers called *celadores*. The constitutional alcalde of Arucas would remain the administrative leader of the Heredad de Arucas y Firgas. By 1835 the question was moot because the new government abolished the alcaldes de aguas and created the civil office of alcaldía (mayorship).

The second related reform was the state's declaration of the Water Law of 1866 which ordered water users associations to establish a democratic governing body; the Heredad created a Junta de Gobierno (Governing Committee), President, and Vice-President to administer it. The committee oversaw the work done by the secretary, the *repartidor* (water divider), *acequieros* (canal workers), *secuestrario* (person who administered the sale of water reserved to pay for the heredad's operation expenses) as well as canal guards, (*celedor* and later publically appointed *guarderias jurados*). In addition, the heredad changed its voting rights. Each member had the right to one vote before 1806. The membership debated reforms until 1858, when voting rights were tied to the amount of water the member claimed; those with less than 1/ 4th an azada had to form coalitions and submit their vote when they reached the 1 azada minimum. As such, the weight of the power within the heredad which had slowly been dispersing among smaller landowners concentrated among the nobility, merchants, and professionals.

The heredad also adopted a 'user pays' principle; those using an acequia would pay a yearly fee for its use and maintenance. The heredad maintained the principle canals by selling *sobras* and the *secuestro*. They also imposed *derramas*, or charges for the water that flowed to the members through sub-acequias, whenever necessary. The most significant effect of these fiscal changes was that the sub-acequias began acquiring a measure of independence from the heredad. The sub-acequias eventually separate officially during the early 20th century when they became the main canal systems for the comunidades de regantes and comunidades de aguas. The sub-acequias running through Casablanca, Rosales, Bañaderos, El Alta, Vega, and San Juan were also reconstructed. The sub-acequias did not install cajas de aguas because the acequieros and farmers themselves monitored the distribution of their water.

The heredad ends both physically and legally at the cantoneras along the principal acequia. The sub-acequias which brought water from the acequia real to the farmers along the coast are administered by their own independent water users associations. Any landowner in the region is automatically a member of the sub-acequia operating in the area. The members elect their own officers, charge annual *cuotas* (dues) which are set by calculating the area and crop under cultivation. Farmers irrigating export crops like sugarcane, banana, tomato, or papaya pay higher cuotas than those irrigating ordinary crops such as corn, potato, or alfalfa. Farmers who are not irrigating land do not have to pay a cuota, but also do not have a right to use the acequias. The sub-acequias occasionally charge additional *derramas* or *cañones* based on the amount of water transported through the acequia. Acequieros hired by the membership or the farmers themselves guide the water through the acequia. The two largest differences between heredades and sub-acequias is that the later has no source of water and does not operate according to a dula. Instead, the farmers instruct the acequieros when and where to send a certain amount of water from a given water source.

In summary, the Heredad de Arucas y Firgas thrived because its members cultivated the best land along the coast and consolidated their control over the Barranco de la Virgen, the greatest source of water in the region. The heredad never faced great threats from highland farmers because the valleys where it collected its waters were too steep to favor the development of a large population. While it did have to hire guards to minimize the theft that did occur above Las Madres, its greatest threat has always been the population in Firgas where the slope of the lands would support greater agricultural production. The heredad's growth and the development of the water market along the coast converted the heredad's acequias and system of measurements into the region's standards.

The Heredad de Tenoya and the Creation of Heredades in Teror and Valleseco.

The history of the Heredad de Tenoya is largely unknown. However, it is clear that as the Heredad de Arucas y Firgas extended its control over most of the water resources in the Barranco de la Virgen, the Heredad de Tenoya gradually lost its grip on the water flowing from Cuevacillas and Madrelagua to farmers in Teror. Their conflicts provide us with another case study of how changes in economic opportunities and techno-environmental conditions altered the distribution of agricultural activities as well as the ability of competing groups to make capital investments and defend their water resources. In this case, the conflicts led to the formation of a loose confederation that is often called the Heredad de Teror and the transformation of the Heredad de Tenoya into the Comunidades de Regantes y Propietarios del Valle de Tenoya (Suárez Grimón, 1992). It also paved the way for the creation of the ayuntamientos in Teror and Valleseco

The preconditions that would make conflict inevitable formed even before the fall of the sugar industry. The Canary Islanders ability to withstand economic downturns had been bolstered by the introduction of corn and potato, among a number of other crop species (Martin Ruiz 1985) Furthermore, some early landowners like Juan de Siberio began selling their land as early as 1527 because they were relatively worthless in comparison to the costal lands during the sugar boom. Most of the other early colonists passed their land to heirs. Thus, enough land had been transferred through inheritance and sales between the 16th and 17th centuries to create a small landed group in the highlands in present day Valleseco and Teror. In addition, the economic downturns during the periods between the sugar, grape, and cochinilla booms prompted coastal landowners to take on landless families as medianieros to work their highland lands. These changes permitted more people to remain on Gran Canaria rather than leave for the Americas during hard times.

The redistribution of agricultural activities created greater demand for water and created a group of highland farmers who both needed water and were nearer to its sources than the original proprietors. Ortiz de Zárate's work with the Heredad de Tenoya demonstrated that its members held proprietary rights to water from the Barranco de Tenoya, up through the Barranco de Arucas, el Pico de Osorio, Teror, and Madrelagua to Los Moriscos (Suárez Grimón, 1992). The members were granted both irrigable coastal lands and highland pastures. happened with the Heredad de Arucas y Firgas and the Heredad del Pinillo, by 1675 the members of the Heredad de Tenoya were either using their water to irrigate their own farms or selling it to others whose farms were located between Tenoya and Transmontaña.

The total demand for water and its geographic distribution changed as farmers extended their fields into the highland between the 16th and 18th centuries. Farmers in Teror cleared forests, built terraced fields, and cultivated subsistence crops. Their deforestation and a pronounced dry spell decreased precipitation just as their very presence increased the total demand for water. Since they could not rely on rainfall to fill their alijbes, they took advantage of their position near the head of the Heredad de Tenoya's canal systems to cut off the water flowing to its herederos along the coast.

Both the highland and lowland groups blamed each other for their water shortages. The dispute went before the Audiencia. The herederos complained that residents from Teror were stealing and usurping their waters. The highlanders insisted that the herederos sold water, and therefore, had more than enough water for their own farms; they wanted proprietary rights to the *sobras*, that is, the water the lowland farmers did not need. In 1677, the Audiencia reaffirmed the Heredad de Tenoya's claim to the water, but ruled that the highlanders could take the sobras. There was just one problem. It never established what constituted 'enough' water and the lowland herederos claimed all of it. The decision did nothing to solve the fundamental problem; everybody wanted water and the herederos could not protect highland supplies. Highlanders took even more water despite the state's unenforceable legal decision (Suárez Grimón, 1988, 1990).

The Heredad de Tenoya offered to rent water from springs in Madrelagua and Arbejales to farmers in Teror in 1739. Their three-year agreement stipulated that water would flow to Teror during the day and to the herederos in Tenoya during the night. In exchange, highland farmers agreed that: 1) nobody would take water during the night; 2) a dula would be formed in Teror during a month long trial period; 3) no water taken during the day would be stored in tanks; 4) no additional acequias would be opened; 5) the alcaldes de aguas from the Heredad de Tenoya could inspect the area any time; 6) infractions on the part of the alcaldes de aguas be reported; 7) the alcaldes de aguas could not interfere with both day and night water capture by Teror neighbors at specified highland springs; and 8) the cosigners of the contract assume the role of administrators and exclude anybody who did not pay for the right to the water (Suárez Grimón, 1990).

The deal made sense to the herederos. They were already losing water and needed to prevent their own alcaldes de aguas and acequieros from selling it to local farmers. But, the residents of Teror got the better of the deal. They acquired contractual rights as authorized users by paying rent and violated the terms of the contract by irrigating even more land with water they took day and night.

The conflict escalated in 1749. Again, the courts defended the Heredad de Tenoya's claim. A year later, when the alcaldes de agua and some herederos went to Teror to close off local acquias and albercones, they were chased away by about 100 men. Despite the fact that Teror's alcalde promised their safety, a mob of over 500 people cornered them in Teror. They escaped only with the help of the local priest. The uprising effectively kept the water under the control of the highlanders (Suárez Grimón, 1990).

The legal conundrum continued until 1866 when the descendants of the herederos from Tenoya returned to court to press what they thought were hereditary property rights. This time, the Supreme Tribunal upheld the Audiencia's decision and ruled that the water belonged to the residents of Teror. The court reasoned that the legal property rights to individuals and the non-juridical nature of the heredades meant that only those individuals who made the rental agreement could submit a claim. Since they were dead, and their descendants could not represent them as members of the heredad, they had no right to the water. In contrast, since the residents of Teror established a contractual rental agreement 130 years earlier, and all of the participants in the contract died, but the water continued to be used in Teror, its residents had established proprietary rights to it. The very nature of the heredad proved to be its own downfall under the new conditions and all the state could do was legitimize what had already happened (Suárez Grimón, 1988, 1990).

The highlanders formed at least 23 heredades or heredamientos in Teror, Arbejales, Madrelagua, and Cuevecillas (Figure 3-3). Most of the heredamientos were confined to the valleys

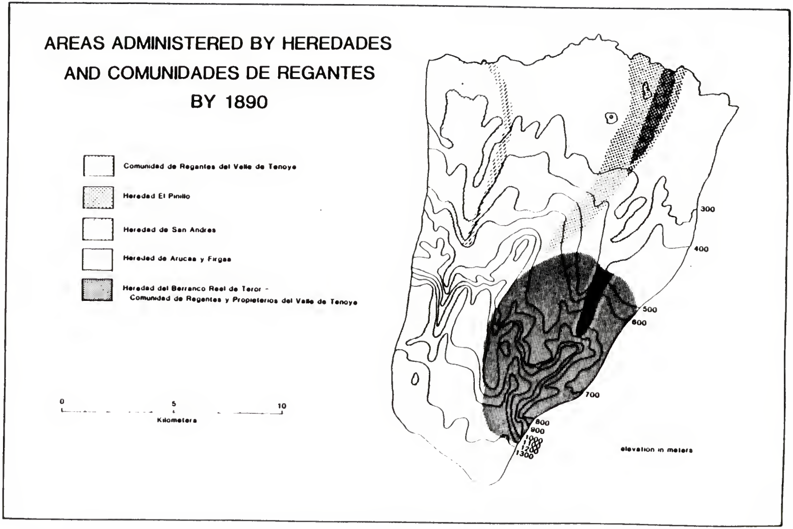

AREAS ADMINISTERED BY HEREDADES
AND COMUNIDADES DE REGANTES
BY 1890
Comunidad de Regantes del Valle de Tenoya
Heredad El Pinillo
Heredad de San Andres
Heredad de Arucas y Firgas
Heredad del Barranco Real de Teror -
Comunidad de Regantes y Propietarios del Valle de Tenoya
0
5
10
Kilometers
300
400
500
600
700
800
900
1000
1100
1200
1300
elevation in meters

Figure 3-3 Areas Controlled by the Major Heredades and Comunidades de Regantes in 1890

where the spring water surfaced (Suárez Grimón, 1990, 1992: 27). All but 5 instituted dulas which limited the amount of time each member could claim water. The heredamientos were largely self-reliant. Their members claimed the water as their own, appointed their own leaders, raised their own money, performed their own construction and repairs, and settled internal disputes. The center of control over water resources shifted towards the highlands which began in the early 18th century was legally only recognized in the second half of the 19th century.

The Heredad de Tenoya would go through one more important change during the 1880s. Its historical conflicts with farmers and the ayuntamiento in Teror suggest that its members reaffirmed their rights to endangered water sources by becoming a *comunidad de regantes*. According to the Spanish National Water Laws of 1866 and 1879, comunidades de regantes were public institutions dedicated to the distribution of public water among proprietors. The members could manage water and exclude non-members from gaining access. The drawback was that they could irrigate only the parcels to which water allocated during specific periods within the dula. While comunidades de regantes made perfect sense on the Spanish mainland, farmers in Arucas, Firgas, and Valleseco could not operate under their rules. Despite the clear legal distinction between heredades and comunidades de regantes, the Comunidad de Regantes del Valle de Tenoya continued to operate like a heredad.

The Creation of the Ayuntamientos

The growth of the Heredad de Arucas y Firgas, the demise of the Heredad de Tenoya, and the appearance of highland heredades occurred during the final days of the Spanish Empire, the Napoleonic invasion, and the birth of the Spanish Republic. A combination of conflicts over land, water, taxes, and church and civil services created strong movements among people in Firgas and Valleseco to separate themselves from the administrative and political capitals in Arucas and Teror. Municipal governments called ayuntamientos were created in all four areas between 1813 and 1894

We have already seen that Firgas' separation from Arucas involved disputes over access and control over the Heredad de Arucas y Firgas' water supply. Now, it is time to examine how the settlement of the highlands created modern day Valleseco and Teror.

Valleseco's separation from Teror began as local residents opened new arable lands and expanded their highland irrigation networks. Suárez Grimón (1992) dates Valleseco's independence movement to 1749, just 9 years after its residents entered the rental agreement with the Heredad de Tenoya. But the separation took 96 years and lasted until 1842. Teror had established itself as an independent civil entity when it broke free from Las Palmas in 1514. It eventually became a religious and national center for the Canary Islands. Teror's church, Nuestra Señora del Pino, was dedicated to the Virgen del Pino, after a young woman claimed to have seen the Virgen Mary near a Canary Island Pine tree. Carlos III expanded Teror's jurisdiction to Valsendero in 1767 because the local religious cult was subordinate to the Virgen del Pino. Thus, by the mid- 18th century, Teror extended from the plains of the Barranco de Tenoya up to Montaña Negrón and down to Las Madres.

A significant portion of Teror's water, arable land, and pasture lay above La Cueta in present day Valleseco. The area was important because Teror received just under half of its taxes from residents in Valleseco's small nuclei such as Valsendero, Zumacal, Zamora, Barranquillo, Casarón, Valleseco, Lanzarote, and Madrelagua. Valleseco's residents also contributed décimos (tenths of all their agricultural produce) and labor to the church but did not often benefit from its ministrations or charity.

Since they had already acquired water, the landowners above La Cueta insisted they could govern themselves and pressed for their own parochial church, ayuntamiento, and grain depository. The most divisive issue was where to draw the borders between Teror and Valleseco because the region supplied the farmers in Teror with much of their water. As Suárez Grimón (1992) says, the solution was Solomonic; Valleseco claimed the area above La Cueta, including Madrelagua. The rest of Valleseco was defined by the borders of the water catchment basin, farms, and property lines of the Heredad de Arucas y Firgas through out the Barranco de la Virgen. Today, the border between Valleseco and Firgas is a large metal gate constructed by the Heredad de Arucas y Firgas to mark its private lands just above the Tomadero de Las Madres where the Acequia Principal begins.

The Dependence of the Ayuntamientos on the Heredades

The fledgling ayuntamientos immediately found themselves utterly dependent on the heredades for their water. As I mentioned earlier, the 134 springs in Valleseco's jurisdiction were controlled by 45 named or unnamed heredades and heredamientos, 17 groups of herederos, and 16 individuals with rights to spring water by 1937 (Ayuntamiento de Valleseco, exp 21(30), 1937). The ayuntamiento's own 39 springs were used by families cultivating the lands near by them. The springs reportedly produced a combined total of 163.16 l/sec or 14,097 m^3/day. That amounts to 32.54 azadas/day (azada = 433 m^3). The true number of springs and their output must be higher because the Heredad de Arucas y Firgas had at least 43 springs but the report only mentions 15. Most of the remaining springs which produced over 1 l/sec were owned or controlled by other heredades and wealthy families including the Marquesa de Arucas, Juan Díaz, Francisco Acosta Suárez, the Herederos of Bartolomé Suárez Hernández, the Herederos de Adén del Castillo, the Heredamientos del Risco Gordo, the Heredamientos de los Llanos de Teror, Manrique de Lara, and Vincente García. The ayuntamiento was left with the least productive springs. Its springs produced a combined total of .45 l/sec or almost 39m^3/day. Its most productive spring, located in Barranquillo, yielded half of that, .22 l/sec. Even so, it occasionally sold water to farmers who had no rights to water if they were in danger of losing their crops.

All of the other heredades complied with the Ordenanzas de Melgarejo by supplying the people of Valsendero, Firgas, Teror, and Arucas with water for non-agricultural purposes. The Heredad de

Arucas y Firgas, the Heredad de Tenoya, and individuals installed abrevadores and lavaderos in their acequias as required by the Ordenanzas. The Heredad de Arucas y Firgas itself opened 81 lavaderos where women washed clothes between 8 AM to 4 PM. The rest of the day was reserved to supply drinking, cooking, and cleaning water. Women and children went to the canals early in the morning and again in the evening to fill ceramic and/or metal containers with water.

The situation was more tense in the medianía and coastal area. Arucas and Firgas both had to rely almost completely on water distributed by the heredades. Their reliance on the Heredad de Arucas y Firgas was almost complete because it controlled the most productive water sources. The 15 notable springs in Firgas produced 9,331 m^3/day. Of those, the heredad managed the springs at El Rapador, Las Madres, Mayorazgo, San Juan, and Los Chorros. Together, these five springs produced 7,226 m^3/day, or 77% of the spring water in Firgas. Most of the water went to Arucas because, by 1810, only 50 of the Heredad's 350 members inhabited Firgas (Quevedo Rosales 1977)

The heredad's traditional obligation created conflicts with the ayuntamientos. As the population in Firgas and Arucas grew, the more citizens watered their animals, filled buckets, and put mangeras (hoses) into the canals to illegally siphon water and irrigate their fields. Whatever they withdrew meant less water for the coastal farmers, who by the 1880s were beginning to feel the rumblings of Europe's demand for bananas. In response, the heredad hired guards to protect its canals. Although absolutely justified from the heredad's standpoint, their guards' zealousness occasionally provoked strong protests from the citizens of Firgas.

The heredad tried very hard to fulfill its conflicting obligation to both members and non-members by granting Firgas proprietary rights to the spring at Los Chorros in the 1880s. In exchange, the ayuntamiento was supposed to prevent residents from extracting water from the heredad's main canal. The trade was not very effective because the canal continued to be the only accessible source of water until the ayuntamiento built its own water distribution system between the 1930s and 1950s so residents took water from both Los Chorros and the canal.

The ayuntamiento of Arucas shared Firgas' dilemma. It owned only 2 of the 13 springs located within its jurisdiction. Don Alfonso Gourie Alvarez donated Fuente del Hierro to the ayuntamiento in 1865. His son, Francisco Gourie Marrero, sold El Norado to the ayuntamiento in 1902 for half its value. The other 11 springs were controlled by heredades and wealthy families. Thus, the ayuntamiento had to rely primarily on the Heredad de Arucas y Firgas for water.

Comunidades de Regantes and the Construction of Reservoirs

All of the springs were guarded jealously by the end of the 19th century when the rise of a seemingly insatiable demand for banana, potato, and tomato throughout a rapidly industrializing Europe provided a marvelous economic opportunity that the Canary Islands had not seen since the rise of the sugar industry. The only thing they needed was more water. Since mining technology was only just beginning to make groundwater mining profitable, the most economical way to boost water supplies was to build a huge network of diversion walls, dams, and water deposits. The demand for surface water was so great that farmers and speculators built as many as 3,030 water deposits on the island (Association of Water Users of Gran Canaria 1980). That includes 711 large tanks, dams, and surface water collection sites on the island (Jiménez Suárez 1990: 55). There are 64 dams larger than 15m in height on the island.

Nobody is sure how many water deposits there really are in the north central region. As of 1970, there were 265 authorizations to capture surface runoff on public lands (Cabrera Hidalgo 1970). There are 4 authorized facilities in the Barranco de Azuaje, another 91 between Azuaje and Tenoya, and another 61 in the Barranco de Tenoya. Together, these hold 3.8 Hm^3, or 27% of the island's surface water. Jiménez Suárez (1990: 57) counted 156 tanks, deposits, and dams from the Barranco de Azuaje to Tenoya. As Suárez points out, the estimate is too low because the administration did not count underground tanks or the smaller holding tanks In fact, a survey in Valleseco conducted in 1944 lists over 300 water deposits (Ayuntamiento de Valleseco, 1944) Each tank is operated by some sort of organization. Residents claim that most are owned and managed by extended families and neighbors Sad to say, I could not find documents to the same survey conducted in Firgas and Arucas, but am relatively sure that the number of subterranean deposits is far lower. Lowland farmers explain that they tend to rely on surface deposits because the geologic features of the area raise the costs of excavation.

Highland farmers either individually or collectively constructed water deposits above and below ground. There are several hundred excavated and water-proofed subterranean tanks to store winter rains in the highlands alone. Deposits along the coast may either be earthen depressions called estanques de barro or stone and mortar tanks. More often than not geological conditions forced farmers to build stone and mortar tanks. Most are rectangular, triangular, or square shaped. They deviate from these ideal types as the topography and geology dictate. Their trapezoidal stone and mortar walls tapper off near the top and their insides are coated with sealant. Reinforced concrete technology made it possible for farmers to construct huge circular tanks. These days, circular aluminum tanks are far cheaper than any of the older tanks.

The relative costs and benefits of building large surface catchments such as reservoirs and dams changed during the Spanish Civil War and World Wars I and II. The combined effects of the international agricultural markets, warfare, urbanization, and an untimely series of periodic droughts made it necessary for farmers and civil governments to initiate or suspend the construction of dams and reservoirs. The relative profitability of the banana market and the technical difficulties surrounding groundwater mining sparked the construction ten dams between 1903 and 1914. Only one was constructed during World War I because neither the farmers nor governments could afford the capital; the capital markets were weak and the armies had to be funded. Another 35 dams were erected during the peace time between 1920 and 1934. Again, only one dam was constructed during the Spanish Civil War and World War Two because the bulk of the government finances were redirected to the military and the interruption of the international produce markets reduced the amount of capital available to private investors. The last surge of construction began in 1945 and ended in 1958 as part of Franco's attempt to create the resources necessary to promote agricultural production and urban based industries. The Spanish State, the Cabildo Insular, and ayuntamientos constructed seven large reservoirs to increase their own supplies on Gran Canaria.

Since the Water Laws of 1866 and 1878 declared all surface waters to be part of the public domain, investors had to acquire concessions which would give them proprietary rights to the water. We have already seen that the Heredad de Arucas y Firgas built the first two dams in the archipelago. The Comunidad de la Vistilla and the Presas del Trapiches y Bañaderos which built two more dams in Firgas. The Comunidad de Regantes de Tenoya built two dams in the Barranco de Lezcano. Don Francisco Rubio built another two dams in Firgas. The Marquesa de Arucas, Doña Carmen Fernández del Campo, and others such as Don Adán del Castillo, Don Francisco Guerra, and Don José Quevedo Franchy built their own dams and canal systems. They built twelve dams in Arucas, Firgas, and Tenoya that hold a combined volume of 2,881,920 m^3 or 2.8 Hm^3, if blessed with rainy winters.

The comunidades de regantes were structurally similar, but not identical to, the heredades. The comunidades de regantes had general and governing bodies. They collected fees, made investments and maintained their facilities, distributed water according to dulas, and settled disputes according to their own formal statutes and unwritten customs. There were important differences, however. As I mentioned before, comunidades de regantes were supposed to distribute public water according to the need the members had to irrigate specific parcels of land. That is not the way they behaved. Promoters for comunidades de regantes offered shares called *participaciones* and *acciones* on the market, and, just like any commodity market, potential investors bid on them. The maximum amount corresponded to units of volume called *huecos* created by the reservoir, dam, or tank. The promoters used the money to build the reservoirs. Speculators could reap sizable profits as market competition guided the price of each of the huecos.

Quirantes (1981) has rightly pointed out that there really was no ecological reason that the comunidades de regantes could not operate according to the formal statutes as they did on La Gomera and La Palma (Reyes Aguilar 1990; Batista Medina 1991, 1995, n.d.). But there was an excellent economic reason; the relatively few people who could make the necessary capital investments profited enormously by selling water and rights if they did not need to irrigate. As such, although the water was nominally a public good, the private investors treated it as a private good. The state did not interfere because its explicit policy was to increase water reserves.

Summary

The major message to take away from this chapter is that the Spanish and Canary Islanders adapted their property regimes to fluctuations in the international markets and local techno-environmental conditions. The heredades formed during an era when colonists and the Crown itself shared an interest in concentrating the water flowing from springs and winter runoff in the highlands along the coast to produce export crops. Since the state had no direct interest in operating the technology or allocating the water, it left these tasks to proprietors who would make the capital investments and benefit directly from the water's use.

After the sugar industry collapsed, an increasing number of farmers moved to the highlands where they could produce subsistence crops. They needed more water than they could collect by capturing rainfall so they competed with lowland farmers for control over the highland springs. The highlanders in Teror succeeded in wrestling a large portion of the water away because they were closer to the sources of water and because the export industry was so weak that the members of the Heredad de Tenoya could not generate the capital necessary to employ guards to protect their water sources and canals. In contrast, the Heredad de Arucas y Firgas grew because the highland area where it collected its water could not support a relatively large population.

The water conflicts over water, land, church contributions, and taxes contributed to the creation of ayuntamientos, which automatically became responsible for providing water to their constituents. Since the ayuntamientos lacked sufficient supplies, they became dependent on the heredades for their water. In a sense, the ayuntamientos became public authorized users of water that had once been considered the state's. The water had since become private because local property holders needed to exchange water on the market independently of land. Furthermore, they could not wait for permission from the distant, and often uninterested state. The comunidades de regantes that appeared in the early 20th century produced more water and thrived in growing agrarian and water markets. Investors did not operate according to the formal norms dictated by the water laws under which they were governed because only a few individuals or major heredades like the Heredad de Arucas y Firgas and the Comunidad de Regantes de Tenoya could make the capital investments in dams while almost all of the farmers in the region needed to purchase additional supplies to take full advantage of European demand for potatoes, tomatoes, and banana.

Notes

1. Fueron las aguas la causa principal de la iniciación y desarrollo de los actuales núcleos de población. Las acequias, obra de las manos de los hombres, esparcidas por todos los rincones cultivables, fueron haciendo posible el nacimiento de caseríos y villas, siempre vinculados al agua, y a la existencia de una heredad (Rizkallal Santana, 1990:49).

2. People in La Palma, La Gomera, El Hierro, Tenerife, Lanzarote, and Fuerteventura talk about "pipas" (pipes). On Gran Canaria, farmers usually talk about azadas. Farmers in Moya or Galdar refer to "azadas de 10 o 8 litros" (10 or 8 l/s).

CHAPTER 4
THE ERA OF GROUNDWATER MINING

The most solid form of wealth in the Canary Islands is the liquid [1]

The European demand for banana, tomato, and potato grew throughout the first half of the 20th century. The strong markets, especially in Spain and England, promoted the formation of comunidades de regantes that built large dams to capture surface water. The strong international agricultural and growing tourist markets coupled with advancements in mining and water lifting techniques also made it profitable to mine the island's groundwater. According to my general model, one would expect that the enlarged capital stocks and new opportunities to mine groundwater more profitably would create greater competition for water rights and cause fundamental changes in the demand for water as well as in water property regimes. That is exactly what happened.

The change in water procurement created a new property regime governing groundwater that was totally incompatible with the traditional property regimes. Groundwater mining favored the creation and proliferation of new water users associations called communidades de aguas at the expense of anyone who held rights to spring water. The shift from the appropriation of spring water to groundwater destroyed most of the springs. It debilitated most of the heredades and forced the rest onto a convergent evolutionary course with the comunidades de aguas and comunidades de regantes. Since the Spanish government was embroiled in tumultuous political conflicts and had to finance its military during the Civil War and World Wars I and II, it had very little capital to subsidize the water projects proposed by the ayuntamientos as their springs dried. The ayuntamientos were forced to make deals with the communidades de aguas to secure rights to water, and thus, became dependent on them as authorized users who could take water, but had no right to manage the mining operations.

In this chapter I will describe and explain how and why the European demand and capital investments in groundwater mining changed the relationships between the Spanish water services, the ayuntamientos, heredades, comunidades de regantes, comunidades de aguas, farmers, and laborers.

Groundwater Mining Technology

Canary Islanders had always attempted to exploit the aquifer but the methods were not cost effective until the banana markets and the introduction of dynamite and lifting equipment made it profitable to construct *galerias* and relatively deep *pozos*. *Galerias* are downward sloping infiltration galleries that are 1 meter wide, 1.8 meters high, have vertical shafts to ventilate toxic CO and CO_2 gases, and often extend more than 1 km into the island's substrata and branch out in several directions. *Galerias* are designed to capture water passively; the empty space they create reduces resistance to water flowing through the island's subsurface. The water follows the path of least resistence, deviates from its normal course, filters through basalt formations, and drips into the shafts. From there it flows through a small canal cut into the floor of the galerias. Most of the galerias lead to the island's surface, although there are some that lead directly to underground water deposits or to pozos. Galerias appear as fairly obscure holes in the surface of the island and are almost indistinguishable from other human-made cavities such as pens, storage areas, and subterranean water deposits.

In addition to galerias, pozos became more popular too. *Pozos* are vertical mineshafts that expose subterranean water and are distinguishable by their design and the means by which they lift water to the surface. The first kind of *pozos* on Gran Canaria were *norias* and *malacates*. There were at least 8 *norias* operating between Arucas and Telde between the 16th and 19th centuries and they became more popular around 1900 when the strong agricultural markets made water even more precious (Moreno 1994). Norias were essentially mechanically motivated chains that dipped down into pozos and lifted water to surface catchments. Norias often consisted of a chain holding 30 to 40 containers that could each store 10 to 20 liters of water. The containers were attached to a band about 1 meter in width and long enough to wrap around a horizontal beam at the top of the well. The beam had a circumference of approximately one meter itself was attached to a pole that could be pushed by oxen. As tethered oxen walked in circles around the pozo, they pushed the pole, and consequently, spun the support beam and rotated the band of containers. The empty containers descended into the water, scooped it up, and rose to the top of the beam where the water spilled out onto a catchment basin or canal as they descended towards the water again. While effective, only the largest norias could produce enough water at rates that made them economical under normal circumstances.

However, the strong European markets at the beginning of the 20th century made them worthy investments. For example, Suárez Moreno (1994) reports 12 norias in La Aldea by 1920. I myself have seen one pozo in Arucas that was excavated before 1900. It has a winding stair case that descends along its walls to the water level. The owner says that it may have operated as a noria before it was equipped with fuel driven motors, electrical pumps, and now a desalinator.

Malacates were basically animal powered water wheels. Draft animals pushed a wooden pole that slowly spun a wooden wheel with containers. The containers picked up water and then rose to the top of the water wheel where the water spilled out into catchments. The most impressive malacate, constructed by the Conde de Vega Grande in 1850 in Jinimar near Las Palmas, has been protected (see Suárez Moreno 1994).

Industrial windmills started making their appearance at the end of the 19th century. The windmills powered impulsion and suction pumps to lift water from pozos. The windmill blades rotated on a vertical shaft so it would always point towards the direction of the wind. As the blades rotated, they caused a metal shaft to rise and fall. That shaft moved several connected horizontal shafts to move laterally, thus forcing a balance with two shafts that jutted upward at 45 degree angles tip back and fourth. It in turn, lifted and dropped a shaft that pumped water either by suction or propulsion

Canary Island merchants, farmers, and merchants like Leacock, Blandy, Sánchez, Santana, Godoy, Castro, and Flietas imported a variety of American, English, and German windmills and/or experimented with the imported designs and produced their own brand name windmills. The Canary Islanders modified them to harness a greater amount of wind energy by adding more blades and lengthening them from 6 to 10 feet to as much as 16 to 22 feet. They also experimented with ways to increase the transfer of energy from the windmill's blades through the gears and moving shafts to the pumps.

The successful application of the technology was matched by excellent international distribution networks and effective local marketing strategies (Suárez Moreno 1994). Since most of the farmers through out the island owned farms less than half an hectare, merchants helped customers finance their purchases by providing credit plans and installation services. The strong agricultural markets and reasonable prices made it possible for hundreds of relatively modest landowners to purchase windmills that they could pay off over the course of a couple of years. As such, windmills remained very popular, especially along the windy coast, between the 1920s and 1960s. But the period in which the windmills dominated groundwater production lasted only about 20 years because steam and fuel driven combustion engines became more effective by the early 1930s. Soon afterwards the tremendous increase in groundwater mining began to cause the water table to drop to levels that rendered ineffective the norias, windmills, and even steam engines.

The generation of pozos constructed between the 1920s and the 1970s are most evident today. They are typically 3 meters in diameter because that is the amount of space needed by two pozeros to safely wield pick axes during their excavations. Pozos may be anywhere from 30 to 700 meters deep. Highland pozos tend to be deeper than coastal pozos which can either capture groundwater flowing towards the sea or seawater pushing inland. In general, pozos anywhere are between 150 and 250 meters. The mine shafts penetrate a fairly large variety of geological formations whose permeability and hardness affect both the cost of excavation and the productivity of the shaft.

Pozeros linked pozos, galerías, caves, with *catas* (horizontal boreholes) and sondeos (vertical boreholes) to form extensive subterranean labyrinths capable of draining huge areas and capturing water with different physical and chemical properties. For example, a pozo with several galerías that shoot off from its central shaft at different depths might produce relatively saline water at the bottom and fresh water in the higher galerías and catas. The different water qualities makes it possible for the producers to customize the chemical qualities of their water; they can either produce brackish and fresh water or combine them to produce a larger supply of relatively saline water. The mazes also enable investors to reduce fuel and pumping costs because water could flow from higher pozos to lower galeras. At this point, the subterranean labyrinth is so extensive that only the few remaining pozeros who have worked since the 1930s know to where most of the tunnels lead.

Pozos are normally housed in white rectangular stone and mortar buildings about 15 meters long, 7 meters wide, and 7 meters high. The area directly over the pozo's shaft is often exposed to give workers enough space to move long pipelines. The rest is roofed to protect the pozo's machinery. The shafts openings are protected by a circular parapet. Pozos rely on lifting technology to bring rubble and water to the surface. Each pozo was equipped with a winch system that raised and lowered pipes, buckets, and metallic rectangular gondolas. Pozos typically have three pipes running to the bottom of the well. Two large pipes inject fresh air into the shaft while sucking up poisonous carbon and carbon dioxide gases. The third brings water to the surface.

Mammoth American and British vapor and gas-oil ship engines which propelled water upward replaced the windmills as soon as they came on the market. The two ton iron engines moved massive fly wheels that moved pistons in the water pipes while providing power for the winch and gas pumps.

Older people from Valleseco tell me that they grew up hearing the pumps echo rhythmically through the valleys. A few of these motors, which can still be heard on quiet days in Valleseco, are highly coveted because they are economical sources of power.[2] Even those that no longer work instill a source of pride; their owners smile and pat their Blackstone-Lister motors as they reminisce about the good old days.

Electrical power and centrifugal pumps introduced in the 1960s automated pozos. They are now operated by computerized control panels that regulate submerged pumps. Whenever sensors detect that the water levels in the shaft reach a certain height, they send an electronic signal to a submerged pump to lift water until the water level falls to a pre-determined minimum. Many of the pozos operate at night to take advantage of cheap, subsidized electricity rates.

The Demand For Labor in the Mining Industry

The demand for labor in the mining industry grew during the first sixty years of the 20th century and has since declined. The greatest demands for labor were concentrated between the 1940s and 1970s when mineshafts were being opened and/or extended and the pumps operated with fuel driven engines. The demand for labor declined because the decreasing profit rates in agriculture and the advent of automatic electronic pumps and plastic piping cut the amount of maintenance that the pozos required.

Pozeros speak with justifiable pride about their physical endurance and the mineshafts they created this century. When building galerias, they used dynamite, picks, and shovels to break through rock which they then loaded onto rail carts and deposited on rubble heaps located near their entrances. Many of the pozos were built during the 1940s, before the modern transportation system made travel relatively benign and construction tools made excavation relatively easy. Only men who could not farm became pozeros because the work was back breaking, low-paying, and very dangerous. Many of the pozeros I've met claimed they cultivated their own farms to grow food because the pay was insufficient to maintain their families. Furthermore, every pozero I know has lost at least one friend to the mines. An engineer who recently studied health conditions in the mines estimates that over 400 laborers died from CO and CO_2 poisoning, cave-ins, falling debris, and falling from the buckets or gondolas throughout the archipelago.

Retired pozeros claim they usually walked several kilometers to the sites where they opened galerias and pozos. Two or three pozeros normally entered the galerias or descended into pozos. If they were working on pozos, three other pozeros operated the engines and winches at the surface. The pozeros who excavated the mineshaft descended into the pozos in small buckets and gondolas and communicated with their compatriots on the surface using a sharp-pitched metal bell. The pozeros developed and used signals to descend, hold, and raise the cable. For example, one ring may mean descend, two rings could mean hold, and three might mean lift. According to pozeros who have worked in the region since the 1930s, no one system ever became the universal standard. Once at the bottom, they siphoned off any water at the bottom so they could excavate. They excavated by detonating dynamite to break the phonolitic or basaltic strata and placed the debris in the large buckets that would bring them to the surface. Once the gravel had been removed, the pozeros installed or extended pipes. After at least 8 hours work, they themselves were lifted to the surface and were often replaced by a second or even a third shift.

Pozos with piston pumps required constant attention of pozeros who were always on call because the pistons frequently ripped their cast iron pipes. Teams of pozeros repaired the damage themselves or carried the equipment to blacksmiths or machine shops. Labor costs declined tremendously with the introduction of computerized, electric pumps and plastic pipes. Now one pozero can monitor several pozos on a display panel from home. These days, pozeros still visit the pozos almost daily to inspect the area, make repairs, sell water, and visit with friends. Many of the pozeros who lost their jobs to technological innovations either retired, found work in the city as skilled laborers, or went to work for bottling factories

Insular Water Production Trends

The historical trends in the volume and cost of water production reflect changes in the economic markets, investments in groundwater mining, and the island's hydro-ecological conditions (Table 4-1). Officials estimate that 1,876 pozos, 431 galerías, and 35 sondeos were opened between 1900 and 1990. Groundwater mining literally destroyed the island's springs by sucking the water out from under them. As groundwater and total water production rose, the amount produced by springs fell from 33 Hm3 in 1990 to 3 Hm3 in 1970. Groundwater production and surface retention became the only major sources of water between the 1950s and early 1980s. During that time, unrelenting competition over groundwater caused the freatic level to fall at a rate of 5 to 10 meters a year. Investors had to *buscar agua* (look for water) by extending their mineshafts every few years. They typically passed the point of diminishing marginal returns to production in the 1960's as the total volume leveled off at 181 Hm^3. Investors extended their mineshafts in a desperate search for water but production rates have been falling steadily since then.

The general historical trends in water production in the north central region are fairly clear, despite the lack of reliable, precise and comprehensive records (Table 4-2). Most of the galerias were opened during before the end of the 1940s. The vast majority of the pozos were constructed between the second half of the 1940s through the late 1950s. In 1981, the Servicio Hidráulico counted 258 pozos and galerías in Arucas, Valleseco, Firgas, and Teror; 76 were in Valleseco, 48 in Teror, 52 in Firgas, and 82 in Arucas. Martín Ruiz (1990: 27) counted 39 productive wells in Valleseco, 20 in Firgas, 30 in Arucas, and 11 in Teror for the same period. Approximately half of these produced less than 5 liters of water per second, and thus, were marginally profitable.

Table 4-1: Total Water Production on Gran Canaria During the 20th century.

Year	Production HM^3	Spring Water HM^3	Surface Water HM^3	Groundwater HM^3	Desalination HM^3	Treatment HM^3
1900	53	33			0	0
1910			7		0	0
1920			8		0	0
1933	74		9	67	0	0
1940			11		0	0
1950	171		11	160	0	0
1960	181		11	170	0	0
1970	166			128	0	0
1988	130		11	107	9	2.6
1993	130	3	11	98	21	6
*1996	131		11	65	38	17
*2002	150		11	29	72	38
*2012	180		11	19	98	53

* Projections.Extrapolated from: Consejo Insular de Aguas (1995); Rodríuez Brito (1983, 1995); Dirección General de Obras Hidráulicas (1974).

Table 4-2 Estimated Distribution of Productive Galerias and Pozos According To Municipality in 1974 and 1993

Productivity of	**Arucas**		**Firgas**		**Teror**		**Valleseco**	
Mineshafts	*1974*	*1993*	*1974*	*1993*	*1974*	*1993*	*1974*	*1993*
Pozos *In service*	25	35	20	20	13	10	48	40
Not in service	45	40	20	25	18	20	11	17
Galerías *In service*	1	1	3	2	2	3	9	10
Not in service	9	2	5	2	12	8	5	6

Source: Dirección General de Obras Hidráulicas (1974); Martín Ruiz 1990; and Consejo Insular de Aguas (n.d.).

The number of pozos and galerías that produce water on a daily basis has declined. These days pozos must pump 10 liters/sec (126 m^3/day) to be profitable enough to operate regularly. Most of the highland pozos were producing less than 5 liters/sec (31 m^3/day) simply because that is as much as filters into the shafts during a 24 hour period. As such, of the 105 pozos listed as producing water in Valleseco, Teror, Firgas, and Arucas, only about a third remain profitable. Most pozos produce water every couple of days but some, especially the saline pozos along the cost, can produce up to 10 liters/sec every day.

The distribution of productive and unproductive mines is heavily influenced by hydrogeological conditions (Figure 4-1). Most of the productive galerías are located in the highlands above the Barranco de la Virgen. These highland galerías are still productive because they are recharged every year by the island's heaviest rainfall. In contrast galerías located in the medianía are more likely to be out of production because they are surrounded by pozos that capture any water that might flow through the local substrata. Conversely, many of the pozos in the cumbre and medianía are less likely to produce vast amounts of water and are more expensive to operate because the water table has fallen about 300 hundred meters in the last 55 years. Pozos located along the coast are far more productive, although most produce water so brackish that it must be mixed either with water from the highlands or desalinated before it can be used for agriculture or public consumption.

Production Costs

Accurate information on production costs is hard to come by, especially if you are not a favored member of a comunidad de aguas or a vendor. Even governments that are considering purchasing water rights and technology may not be given exact production figures or costs. Their engineers have to estimate them. Fortunately, the ball park estimates that owners and public officials make are fairly consistent. In general, the oldest technologies remain the cheapest ways to produce

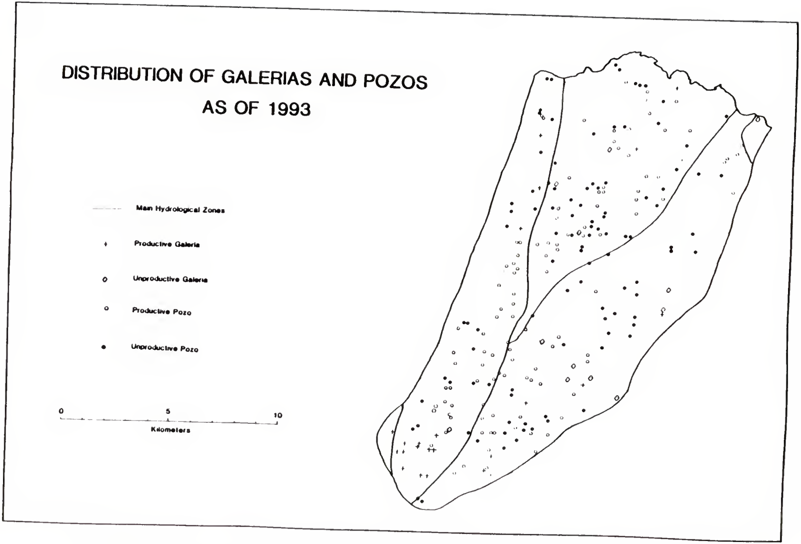


Figure 4-1 Distribution of Productive and Unproductive Galerias and Pozos in 1993

water. Galerias are the cheapest technology but the amount of water they produce is limited by rainfall (Table 4-3). Pozos are roughly 4 to 7 times as expensive to operate as galerias.

The difference between nominal and inflation-adjusted costs are especially important because it contradicts one of the most prevalent beliefs about water management in the Canary Islands. Virtually everybody insists that the production costs skyrocketed. Older Canary Islanders constantly refer to the cost of water during the 1950's when complaining about its cost today. But they are concentrating on nominal costs. Once the cost of production is adjusted for inflation, the costs of operating galerias and pozos appear fairly constant. In 1974, it cost an average of 8 pts/m^3 (53 pts/m^3 in 1990 pesetas) to produce water from a pozo and 5 pts/m^3 (33 pts/m^3 in 1990 pesetas) in a galeria. Twenty years later, pozos operating in Arucas and Firgas cost anywhere between 5,000 to 11,000 pts/azada. That comes out to 30-66 pts/m^3 or 23-51 pts/m^3 in 1990 pesetas.

The relative stability in production costs is not much of a mystery. In 1974, the average cost of labor, energy, and amortization each represented about 27% of the total investment for pozos that produced less than 50,000 m3/yr (or 301 azadas at 166 mm). The combined cost of maintenance and repairs, continued excavation, and other things such as administration accounted for less than 18%of the total annual cost. Computerized pumping technology reduced labor costs by about 88% because it only takes one person to work 13 hours a week rather than 3 people for 120 hours a week to operate a pozo. The falling labor costs didn't reduced the total cost of production because the expensive equipment had to be amortized and fuel and materials costs rose. Galerias still cost about 3 pts/m^3 (1990 pesetas) to operate primarily because the passive infiltration systems do not require energy and labor and material costs are minimal -- as long as there is no need to extend the mineshafts.

From Surface Water to Groundwater

Now that I've laid out the basic changes in technology and its cost, it is time to examine how

Table 4-3 Changes in Average Nominal and Real Production Costs for 1974 and 1995

	1974		1994	
Source	Nominal Price per m^3	Price per m^3 (1990 pts)	Nominal Price per m^3	Price per m^3 (1990 pts)
Galería	5	33	10	8
Pozo	8	53	30-66	23-51
Desalinating Groundwater				62-93
Desalinating Seawater	47	315	96-143	74-111
Waste Treatment (2 stages)	0-13	67-87	80	62
Waste Treatment (3 stages)			155	120

Sources: Dirección General de Obras Hidráulicas 1974; Jiménez Suárez (1982); field interviews.

the changing markets and technologies lead to the creation and ascendance of the comunidades de aguas. By the late 1880's, the demand for water was so strong that water became more valuable than the land it irrigated. Farmers and speculators hoping to sell water for profit on the water market rushed for land and property rights as well as government concessions to public water sources and mining rights. In its effort to increase water production rates, the state granted over 5,000 concessions to surface, spring, and ground waters between 1924 and 1990. It granted 265 of the 657 applications for concessions to capture runoff on public lands. Over half were granted before 1935. Twenty six heredades and 31 comunidades registered their existing rights to public spring and surface waters. Heredades acquired 48 of public concessions. Comunidades de regantes secured another 32. Individuals acquired 149 concessions. Civic communities acquired 6. Another 195 applications were either initiated, archived, closed, or denied. (Cabrera Hidalgo 1970).

The competition for groundwater mining rights was far more intense than for rights to surface water. The rush for groundwater mining rights changed the institutional profile of the island's water producers. In the early 1980s, the Association of Water Users of Gran Canaria counted 47 heredades, 24 comunidades de regantes, 480 comunidades de aguas, and 43 other kinds of water users associations on the island. There was a total of 30,675 shares to water in all of the organizations. The state granted 4,599 authorizations to build or modify pozos, 610 for galerías, 39 for sondeos, and another 294 other unspecified activities between 1924 and 1990. Public records show that 1,876 pozos, 431 galerías, 35 sondeos and 16 other shafts were opened (Consejo Insular de Aguas de Gran Canaria 1995: 46). The vast majority were opened on private lands.

Records from the Jefatura de Minas y Aguas and the Consjería de Obras Públicas indicate that most of the mining rights distributed in the north central region of Gran Canaria belonged to individuals (Table 4-4). However, this is misleading. The applicants tended to be a small core of speculators who applied for concessions and later transferred ownership to comunidades de aguas.

Table 4-4: Number of Mining Concessions Going to Individuals, Heredades, and Comunidades de Aguas According to Municipality

Municipality	Individuals	Heredades	Comunidades de Aguas	Total
Arucas	160	7	23	*190*
Firgas	144	6	55	*205*
Teror	190	81	42	*313*
Valleseco	203	35	38	*276*
Region	*697*	*129*	*158*	*984*

Source: Cabrera Hidalgo (1970: XXXII)

Comunidades de Aguas

Farmers and speculators could only reap the benefits of the international market by making substantial investments in groundwater mining. Investors who specialized in opening mine shafts scoured the valleys in search of potential places to mine water. They hired dowsers and hydrologists and rushed to Las Palmas to propose mining projects whenever they found a likely site.

The most powerful landowners used their proceeds of the crops they cultivated and sold to Spanish and British distributors like Fyffes and Elder Dempster to prospect for water. If that was not enough, they turned to Spain's emerging financial sector to take out loans. Since most farmers could not open their own private wells, they pooled their capital in joint ventures. Prospective investors formed comunidades de aguas to make the financial investments and, if they struck water, to manage their mutual interests.

While the comunidades de aguas were modeled on heredades, they had significant proprietary, structural, and operational differences. Unlike heredades which appropriated public and private spring and surface waters, the comunidades de aguas appropriated water that was considered *res nullis*. The National Water Laws of 1866 and 1878 operated on the principal of appropriation; groundwater acquired in mineshafts belonged to individuals only after they brought it to the surface. The Canary Islands had long conformed to the Roman principle which states in Spanish *'desde el cielo hasta el infierno'* (from heaven to hell). In other words, the individual who owns the surface owns the right to exploit all that above and below the surface area. Therefore, anybody or any comunidad de aguas which wanted to open a galería or pozo had to acquire mining rights to the land above the shafts -- even if the owner did not own the water itself.

Members of comunidades de aguas could only claim ownership of portions of the water that had already been brought to the surface. Each share represented a unit of time that water would be allocated to the shareholder. Investors sold shares on what essentially became a highly speculative water futures market to raise the venture capital they needed to open mineshafts. The number and price of shares depended on rumors concerning the productivity of the mine and the need for capital. The members also sold water kept in secuestros and charged cuotas to cover production and administrative costs. Speculators won and lost family fortunes repeatedly in their search for the next big strike and honest business partners.

The comunidades de aguas allocated water according to dulas whose lengths were determined by the number of shares in the organization and daily production rates. For example, the comunidad had 100 shares and its pozo produced two azadas a day, then its dula was 50 days long. A pozo that produced 2 azadas a day and had 30 members could form a dula of 15 days. The number of people who received water on any day depended on the size of their shares.

The comunidades de aguas established a variety of formal voting procedures. Most were tied to the distribution of shares. For example, the misnamed Comunidad de Regantes La Guancha gave everybody with less than three shares one vote and another for every three additional shares. The Comunidad de Aguas Las Huertecillas used a progressive voting system, members with 3 shares had 3 votes, those with 6 shares had 5 votes, and anybody with more shares had 6 votes. The Comunidad de Bienes Huerta de Los Pinos stipulated that members had to have at least one share to vote. Beyond that, each share entitled its owner to another vote. The voting system concentrated power within the communidades de aguas among the largest owners, just like any publically held corporation.

Competition over property, the distribution of voting rights *within* the comunidades de aguas, and the risk of lawsuits and taxation made owners extremely sensitive about secrecy. They rarely notarized their holdings in public or even in the comunidades de aguas themselves. Deeds more than 50 years old are often still accredited to their original owner despite having been transferred repeatedly Rather than sign any document, new owners simply inform the administrators of the exchange

According to some disgruntled veterans, people whom members thought were minority shareholders quietly purchased shares until they could take over the comunidades. Minority share holders complained that the principle investors and administrators lied about the productivity of the mines to boost the market price of the shares. They also complained that the principle investors frequently manipulated their accounts to shift the bulk of the costs onto struggling shareholders whom could neither afford the inflated charges -- nor lose their access to water. In sum, minority share holders argue that they were milked for their money and forced to sell their shares after the comunidades struck water and they ran out of money to cover their share of the comunidad de aguas' monthly and annual operating fees.

Property rights *among* comunidades de aguas and heredades became highly concentrated too. Farmers and speculators essentially formed investment clubs to open several wells at a time to hedged their risks against unproductive wells and, if lucky, acquire a continuous supply of water. In many cases, farmers purchased shares to comunidades de aguas that operated wells in other areas of the island even when they could not irrigate with the water. These investors sold the water for profit and then used the money to purchase water from suppliers nearer to their own fields.

The concentration of capital among the upper class and the administrative roles played by the educated professionals created a small class of owners, administrators, and vendors that quickly gained control over most of the comunidades de aguas, comunidades de regantes, and even the heredades. The concentration of power is evident today; 44 individuals administer 47% (128) of the 272 water users associations listed in public records on Gran Canaria. Canary Islanders claim that as few as 10 extended families who speculate on the water market have largely controlled the water supplies during most of the 20th century. Thus, the institutions that produced water grew more interested in sales and profits rather than farming or domestic consumption.

The Distribution of Water Property in the North Central Region

The spectacular rise of groundwater by individuals, heredades and comunidades de aguas was quite apparent in the north central region too. At least 120 different comunidades de aguas, comunidades de regantes, and heredades with a variety of rights to surface, spring, and groundwater operated since the 1940s (Table 4-5). It is fairly clear that ownership and control over most of the operating mineshafts in the region is highly concentrated among vendors and farmers who irrigate lands in Arucas and Firgas. The Heredad de Arucas y Firgas owns at least 13 mineshafts in Valleseco. Aguas de Firgas, a bottling plant located in Firgas, recently purchased pozos from struggling farmers in Valleseco so it now owns about 14 mines in the lower reaches of Valleseco and upper Firgas. Together, they own most of the water sources from Montaña Negro to Las Madres. Furthermore, the old noble and merchant class families (Manrique de Lara, Massieu de la Rocha, Massieu y Fernández, Cambrelén, Armas, Campo, Hernández Suárez, Ponce, Blandy) and vendors seem to have the greatest property holdings through out Arucas, Firgas and Valleseco..

The flip side to highly concentrated rights to water is a remarkably diffuse distribution of minority shares. As is evident by the distribution of water rights within the Heredad de Arucas y Firgas, the number of individual holding relatively small shares to comunidades de aguas, heredades, and comunidades de regantes is very large. Most extended families through out the archipelago have some proprietary or ownership rights. Siblings often share water from their parent's dula or sell its water if they no longer farm.

The Conflict Between Incompatible Property Regimes

Canary Islanders saw trouble coming as early as 1873. The archipelago's most prominent citizens wrote an insightful, urgent essay about the dangers raised by the potential for groundwater

Table 4-5 Comunidades and Heredades as of 1989

Cdad Alto Las Rosadas
Cdad Barreto
Cdad Benartemi
Cdad Blandy
Cdad C.E.R.A
Cdad Calderetas
Cdad Canal Norte-Sur
Cdad Casas Viejas
Cdad Charco Las Palmas
Cdad Charquito
Cdad Cortijo Corcho
Cdad Crespo
Cdad Cuatro Esquinas
Cdad Cueva El Hoyo
Cdad Cueva Matos
Cdad Cuevecillas
Cdad El Cardón
Cdad El Castañero
Cdad El Silillo
Cdad Galería El Hoyo
Cdad Heredad El Alamo
Cdad Heredad La Romera
Cdad Heredad de Arucas y Firgas
Cdad Heredad de Los Llanos
Cdad Heredad de San Làzaro
Cdad Hoya La Palma
Cdad Hoyas Las Madres (Suerte La Virgen)
Cdad Huerta Los Pino
Cdad Huerta Los Pinos
Cdad La Arena
Cdad La Asomadilla
Cdad La Cordillera
Cdad La Cumbre
Cdad La Fuentecilla
Cdad La Gloria
Cdad La Hidràulica
Cdad La Hiedra
Cdad La Solana
Cdad Las Toscas
Cdad Llano Grande (Cdad. San Vicente)
Cdad Lomito Pelado
Cdad Lomito del Monte
Cdad Lomo Blanco
Cdad Lomo del Pino
Cdad Los Alfaques
Cdad Los Barriales
Cdad Los Charcos
Cdad Los Nueve
Cdad Los Tanques Esparter
Cdad Madrelagua
Cdad Pozo Cirilo
Cdad Pozo Corcho
Cdad Pozo Doña Felisa
Cdad Pozo Doramas
Cdad Pozo El Carmen
Cdad Pozo El Cortijo
Cdad Pozo El Gusano
Cdad Pozo El Hoyo
Cdad Pozo El Palo
Cdad Pozo El Porraldillo
Cdad Pozo Las Nieves
Cdad Pozo Las Toscas
Cdad Quevedo y Parrales
Cdad Quiebramonte
Cdad Risco Caido y Cuevas de Lana
Cdad Risco Gordo
Cdad Risco Gordo y Charquitos
Cdad Sacristan
Cdad Valsendero
Cdad Virgen del Pino

Table 4-5 Continued: Comunidades and Heredades as of 1989

Cdad de Aguas El Carmen
Cdad de Aguas El Hoyo
Cdad de Aguas El Rayo Hoya Alta
Cdad de Aguas Heredad de Los Nueve
Cdad de Aguas Hoya La Palma
Cdad de Aguas La Gloria
Cdad de Aguas La Somadilla
Cdad de Aguas Llano de la Linde
Cdad de Alcantarilla Pozo Los Llanetes
Cdad de Bienes El Pino
Cdad de Regante Trapiche y Bañaderos
Cdad de Regantes Buenavista
Cdad de Regantes Casa Encamada
Cdad de Regantes Casas Viejas
Cdad de Regantes Chamartina
Cdad de Regantes La Hiedra
Cdad de Regantes La Rajita
Cdad de Regantes Madrelagua
Cdad de Regantes Nuestra Señora de la Candelaria
Cdad de Regantes Pozo La Junquera

Cdad de Regantes Pozo Vegeralta
Cdad de Regantes Pozo de Cuevecilla Condecilla
Cdad de Regantes San Isidro
Cdad del Pinillo y la Pila
Cdad los Alfaques
Fuente El Guanche
Heredad El Alamo
Heredad El Borbullón
Heredad La Madresilla
Heredad Los Llanos y La Romera
Heredad de San Lázaro
Heredamiento El Chorrito
Heredamiento de Las Presas de Tenoya
Heredamiento del Barranco Los Gruados
Monteverde
Pozo La Ensillada
Pozo Los Alamos
Pozo Los Espignones
Pozo del Llano Grande

mining given the National Mining Laws of 1859 and 1868, the Civil Codes, and the Water Law of 1866 (Amigos del Pais, 1873). They explained that the hydrogeological nature of the islands and their reliance on springs made groundwater mining a potential threat to their property holdings, and by extension, to their well being. They agreed that more water had to be procured and did not reject groundwater mining. Instead they asked the government to find ways to encourage mining without destroying their organizations or access to water. In particular, they asked the state to answer a number of difficult questions. Who owned the rights to mine water — the owner of the soil, subsoil, the state? Who owned the soil and subsoil? How deep was each? Who owned spring and subterranean water before, after, and as it was brought to the surface? Who owned the transportation networks? How would the market price of water be set? What was the state's role in normal and drought years? How would individuals be compensated for the loss of their springs?

The questions raised in the open letter could never be answered to everybody's satisfaction even though the Spanish central government gave the Canary Islanders permission to formulate laws, proclamations, and regulations they thought would suit their own peculiar hydrogeological and sociocultural conditions. Canary Island water law became complex and contradictory. State and local administrations could neither monitor activities nor apply statutes consistently. Investors initiated costly and lengthy administrative and legal battles whenever necessary, but normally minimized their contacts with the public agencies and conducted their business as they saw fit. Civil administrations made decisions in 2,050 disputes arising from Gran Canaria, and to a lesser extent, Lanzarote and Fuerteventura. National authorities such as the Consejo de Estado (State Council) or the Ministerio de Obras Públicas (Ministry of Public Works) issued 52 ministerial declarations. Of the 855 cases that the Spanish Supreme Tribunal addressed between the 1920's and early 1970's, 207 or 31.8% were water disputes from the Canary Islands. Gran Canaria alone produced 81% or 167 of these cases (Pérez Afonso 1974: 9).

Litigants often settled their water disputes out of court by ruthlessly competing over water supplies. The Spanish Civil War provided many with the opportunity to use the national struggle over political power as an effective devise to remove their competitors. Retired farmers estimate that at least 50 people from Arucas and Firgas were thrown off towering cliffs by the Guardia Civil during the Spanish Civil War because their opponents in land and water disputes falsely accused them of being communists. Residents in Montaña Cardones claim that the executions became so common that their parish priest, Father Deniz, won their hearts and respect by keeping nightly watches in his church tower to guard intended victims. Legend has it that he ended the Guardia Civil's executions by appealing directly to his friend, General Franco, during a state visit.

Unfortunately I cannot discuss any particular cases because I don't know of their details. It would be particularly interesting to find out what kind of people were usually targeted for execution. Were they individuals who illegally irrigated with water flowing through canals? Were they competitors trying to open mineshafts near their accusers' own projects? Were they farmers whose springs were drying and filed legal complaints that were potentially ruinous to the comunidades de aguas? Were they wage laborers who engaged in union activities? What is particularly important here is that the issue provoking the executions was not political ideology but conflicts over water and land during the greatest boom market that the island had seen in centuries. Most of the farmers in the region were illiterate and had never traveled abroad apart from military expeditions. There were relatively few people who worked as wage laborers, although the labor movements had reached Arucas. Appeals to political ideology during the civil war were simply effective tools to battle over resources. They were not the principles guiding the behavior of the Canary Islanders.

The process by which the dominant property regime shifted from private ownership and proprietary rights to surface and spring waters to ownership rights to groundwater is most clearly seen in public records concerning mining concessions. The Spanish government's explicit policy was to foment groundwater mining while balancing the competing interests of farmers, speculators, and ayuntamientos. The growing demand for water, the capital investments in rapidly improving groundwater mining technologies, and the hydro-geologic nature of the aquifer brought two legal principles into conflict. The Water Laws of 1866 and 1878 stated that groundwater belonged to those who brought it to the surface while also reaffirming the legitimacy of existing rights to springs. The two property regimes were physically incompatible; both would not survive.

Most of the legal battles centered around the Royal Order of November 27, 1924 which stated that third parties would be protected while setting a safety zone of 100 meters around existing sources. It also required applicants to submit: a project description; information about any relevant public and private institutions that would be affected; maps and drawings; relevant technical and legal conditions. Petitions to mine public lands also had to enclose a budget. Those wishing to mine private lands had to submit: a project description; proof that the investors possessed the rights to mine the subsoil; and maps and drawings. Once it had this information, the *Jefatura de Obras Públicas y Minas* (Department of Public Works and Mines) announced the project in the Canary Island Official Bulletin and required the ayuntamientos to display it for 10 days during which time anybody could submit an *oposición* (objection). Afterwards engineers reviewed the project on its hydrogeological, economic, and legal merits. The director of the Jefatura de Obras Publicas y Minas (and later the Servicio Hidráulico and the Jefatura de Minas) used the reports to make recommendations to the Civil Governor who made the final decision. Anybody who objected to the decision could bring the dispute before the civil courts.

Today, some water managers from Arucas explain that the heredades and heredamientos lost their springs because they "slept on their rights". In contrast, older residents from Valleseco and Firgas denounce neighbors who sold their mining rights as greedy people who utterly lacked a moral, social conscience. I prefer an alternative explanation. The people who sold their rights simply responded to tremendous capital incentives and the threat of losing their own water during the rapid intensification of the agricultural sector. The investors' rush for mining rights put landowners in a classic prisoner's dilemma in which the safest choice was to sell mining rights even though it would harm family and neighbors alike. Everybody knew that opening a pozo or galería would probably redirect the flow of water from the springs to the wells. Investors enticed landowners into signing over their mining rights by trading them free shares called *libradas* for 5 or 10% of the water that the mine might produce. Landowners who accepted the deal stood to gain more water than they had although everybody else around them would loose their spring. If they declined the offer, they risked seeing their neighbor accept it. Given the risk, landowners eagerly 'stuck their hand in the jar of *gofio*' first.[3]

Thousands of objections were filed. Some of the heredades and comunidades even established safety zones they would protect as a matter of habit. For example, the Heredad de Arucas y Firgas regularly opposed any project located within a 3 km radius of its own sources. While some of its justifications for blocking projects were persuasive judging solely from the close proximity and scope of the proposed works, others required more debatable theories. Don Juan Ponce Castellano, President of the Heredad de Arucas y Firgas formulated the *teoría ambulante* (ambulatory theory). The theory stated that the complex nature of the subterranean geology made it possible for mineshafts to redirect natural subterranean flows and damage springs and wells that were located as far as several kilometers away (Jefatura de Obras Públicas y Minas exp. 688; 1922). In his letter of opposition to a project proposed by the Comunidad Hidráulica de Valleseco in 1940, Castellano argues that:

> The grave danger of capturing and distracting all or at least part of these spring waters from El Rapador and Las Madres, which belong to the heredad, finding themselves some three kilometers from the indicated proposed well and the last being the most distant. The configuration of soils and subsoils in that zone makes it manifest even to the eyes of the most profane, that this inveterate danger to the heredad of my Presidency, is not an imaginary or illusory thing, but a manifested and tangible reality.[4]

Although the theory was ridiculed by investors, the Chief Engineer of the Jefatura relied on it to revise or reject this and at least 2 other mining petitions at Los Sauces (Jefatura de Obras Públicas y Minas exp. 1448) and Cueva de Bolos (Jefatura de Obras Públicas y Minas exp. 1034). In his decision regarding the project proposed by the Comunidad Hidráulica, he wrote,

> It is likely, that at such a distance, the projected works would not affect the said spring, but given its importance, and the impossibility to assure that the galerías will not cut some of the veins which feed it, it appears prudent to authorize only one pozo at this moment, which has a much smaller influential radius.[5]

Despite invoking the ambulatory theory on some occasions to protect important springs, the Jefatura authorized pozos and galerías located slightly more than 100 meters from less productive springs and subterranean works. In these cases, the director relied on legal logic that was compatible with the Ambulatory theory. For example, in 1941, Don Francisco Rubio Guerra, President of the Heredad de San Andrés, opposed a proposal to open a pozo with two galerías shooting off from the central shaft at Hoya del Pino in Firgas. Ignoring the fact that his own heredad was locked in its own dispute over its efforts to mine groundwater in the valley, Don Francisco argued that the project would destroy the valley's springs and, thus, its heredades. In response, the technical engineer argued that the 100 meter requirement could not block the project:

> For our part, we reply that if the law presumes, as the complainant claims that juris et de jure, certain danger exists under 100 meters, the same law presumes equally, juris et de jure, that the certainty disappears beyond 100 meters.[6]

How can anybody reject proposals because pozos or galerías might destroy springs located approximately 3 km from the proposed site and beyond existing works, yet authorize others in regions where disputes are already raging? The answer is that, just as the ambulatory theory states, the complex geomorphological conditions on the island made it impossible to precisely determine how any facility would affect other sources of water. Officials could justify granting concessions in most of the cases and had every economic incentive to do so.

Knowing that the odds that the government would approve projects located close to their own was fairly high, property holders developed a defensive tactic; they proposed to build rings of mines just over 100 meters from their own springs or shafts to prevent anybody from mining within 200 or 300 meters. This is why only a fraction of the pozos that the government authorized were ever constructed; most of the proposed pozos served an entirely defensive purpose. Of course, the trick didn't always work. In 1943, the Chief engineer criticized it in a memo concerning a proposal to construct a pozo with two galerías shooting out from the shaft in Valleseco's Barranco El Andén. He wrote,

> This is one of the many absurd projects that heredades sometimes solicit, perhaps not with the desire to execute them, but rather to impede others from coming to exploit water in the valleys they themselves consider their exclusive property.[7]

The Jefatura de Obras Públicas y Minas did everything it could to pack more mineshafts into the region. It reoriented, shortened, and redesigned proposals rather than simply reject them. In some instances, it allowed investors to open galerías and catas almost up to the 100 meter limit or up to property boundaries. It occasionally required investors to wait several years to see if a previously approved project would be built. If not, the new investors could proceed. It also authorized projects under the condition that they be constructed in stages so the Jefatura could estimate its effects on nearby sources. In at least one case, it authorized a project as long as the recipient would habitually shut down the pozo's pump so that water would descend towards another pozo located a little more 100 meters below it.

Droughts Before the Storm

In the midst of these mounting conflicts, a succession of severe droughts between 1936 and 1944 reduced the amount of water spring water and nightly precipitation. Municipal governments throughout the Canary Islands reported miserable harvests. The Spanish Civil War and World War Two aggravated the situation because export markets declined and the Spanish army confiscated staple farm produce while requiring ayuntamientos to quarter state militia. Landless and landed people alike in Valleseco, Teror and Firgas staved off famine by dry farming, earning money through wage work on banana plantations or as laborers constructing pozos, galerías, roads, and electrical power lines, or migrating. People living in Valleseco subsisted primarily on gofio, potatoes, and vegetables that they grew themselves or purchased from the stores opened by the owners of the coastal banana plantations. They considered themselves fortunate to acquire an egg or meat and acquired the bulk of their protein by drinking a mixture of cow and goat milk called tabique.[8] Meanwhile lowland farmers who had water cultivated subsistence crops next to their export crops and sold both to hungry laborers.

The ayuntamientos confronted the prospect of having to support impoverished populations while seeing their springs run dry. The ayuntamientos made more relief loans to families, just as they had since the mid-19th century, and redoubled their efforts to acquire national funding for public works. Most of the municipalities made urgent pleas to the central government for aid to secure potable water and more aid money. Since the national government was already strapped by the war efforts, they characteristically refused to help ayuntamientos explore for groundwater. The alcaldes were left to consider three options. They could expropriate water, tax water production, or acquire their own *libradas*.

The ayuntamientos could not afford to either buy or expropriate water. Even their attempts were usually blocked. For example, In 1938 Valleseco's alcalde, Don Juan Rodríguez Santana tried to expropriate water from the Comunidad de Crespos, which was owned by the powerful Manrique de Lara family. The ensuing legal disputes were only resolved in the 1970's when the ayuntamiento signed a contract to buy water from the comunidad on a regular basis.

Unable to protect Valleseco's springs, Rodríguez Santana tried to tax the water produced within the municipality and transported elsewhere. The Ministerio de Hacienda initially approved the tax but reversed its decision after enraged farmers, comunidades, heredades, ayuntamientos, and state ministries correctly pointed out that the policy was tantamount to double taxation, irrigated lands were taxed at higher rates than dry lands in the municipalities where the water would be consumed. They opposed any attempt to tax water because it would harm agricultural production, and by extensions, profits, state tax revenues coming from agriculture, and the general well being of the society itself. None the less, the conflict shows how desperately highland farmers and alcaldes struggled to maintain their grip over water supplies. But they were outmatched. The national and insular governments, lowland ayuntamientos, and coastal farmers were just as anxious to acquire more water.

The state encouraged the ayuntamientos to solve their water supply problems by making deals with the heredades and comunidades de aguas for rights to springs and/or water produced in mineshafts. We have already seen that the Heredad de Arucas y Firgas granted Firgas rights to water flowing from Las Chorras. Arucas relied on the Heredad de Arucas y Firgas too, but also possessed springs donated or sold by the Gorié family. Rodríguez Santana didn't have any wealthy individuals willing to donate springs, so he had to find a way to ensure the citizens with domestic water supplies while permitting groundwater mining to proceed. The best way to do that was to intervine directly in a dispute with groundwater investors whose projects would directly harm a spring to which the ayuntamiento held rights. Rodríguez Santana suspended the construction of a galería at Las Gabrielas in the Barranco Risco Gordo because it threatened to destroy the spring whose *sobras* belonged to the municipality. The situation became even more complicated because the Heredad de Risco Gordo had already submitted its own application for mining rights in the area and most small farmers opposed both projects. Deniz Sánchez who proposed the galería struck a deal with the Heredad de Risco Gordo and the ayuntamiento in 1943. The ayuntamiento rescinded its objection to the project on the grounds that the water be measured by the standard set by the Heredad de Arucas y Firgas, farmers be permitted to purchase water at the prevailing market price, and the ayuntamiento be given 1.5 liters/sec and the right to purchase more at a discount of 20%. The deal was extremely successful because it ensured the ayuntamiento with water people in the valley of Valleseco until the early 1970's when the galería's productivity declined. The ayuntamiento made similar deals with other comunidades de aguas.

Given the dangerous shortage of public drinking water and the heightened need for irrigation water, the ayuntamientos became directly involved with the private distribution of water and the operation of the water market. The Gobernador Civil on Gran Canaria issued several proclamations during the late 1930's and early 1940's to regulate the prices and distribution of water, seeds, fuel, and agricultural produce. He ordered the ayuntamientos to cooperate with water vendors and farmers to protect subsistence crops.

Fortunately a few of the records of the meetings about the state's regulation of the market in Arucas have survived. On March 14, 1941, the Alcalde of Arucas, Ramón Suárez Franchy, met with Pedro Hernández Pérez (owner and vendor), Antonio Codorniu Quevedo and Rafael Henriquez Marrero (buyers), and Juan Falcón Hernández (vendor) to solve the water shortages.[9] Pedro Hernández Pérez stated that there was no way to supply all of the farmers with water. He estimated that all of the heredades combined produced 720 azadas every 31 days in 1938. (I don't know how Hernández Pérez came up with this estimate because the Heredad de Arucas y Firgas produced 744 azadas by itself.) He went on to say that the comunidades de aguas and individual owners produced another 500 azadas during the same period. Thus, the total amount of water available amounted to at least 1,220 big azadas or 353,000 m^3 every 31 days. Hernández Pérez estimated that there were 1,000 fanegadas (550 ha) of banana crops in Arucas. Since each needed 500 m^3 of water for every fanegadas, they needed 500,000 m^3 every month. The demand for water destined just for agriculture was at least 150,000 m^3 or 517 azadas greater than the supply. He didn't even include the demand for urban supplies. Despite increases made by the pozos and galerías opened between 1938 and 1941, 4 years since the first report, Perez estimated that they still needed at least another 250,000 m^3 or 862 azadas a month.

The following year, the ayuntamientos of Arucas and Firgas surveyed the farmers to estimate their water holdings and needs. The survey in Arucas indicated that there was about 1604 fanegadas (882 ha) of banana in cultivation, but the owners of 440 fanegada (242 ha) were waterless. In addition, farmers were growing 88 fanegadas of potatoes (48 ha), 155 of boniato (85 ha), and 250 fanegadas (138 ha) of corn. There were about 280 farmers without any water. Another 189 had water, but only 32 had enough to get by without purchasing any on the market. Since the droughts and wars created a strong demand for subsistence crops, banana farmers took advantage of flood irrigation by multi-cropping.

The curious thing about the survey is that most of the water came from the Heredades de Arucas y Firgas, El Pinillo, La Padilla, San Andres, El Porrón or Quintanilla, La Chacra, and the Comunidad de Las Arenas. It didn't mention the other comunidades de aguas. There are several obvious explanations: 1) the comunidades de aguas were largely owned by speculators, not by farmers; 2) many of the comunidades were not yet pumping water; and 3) the farmers were being less than honest about their water needs and holdings. All three probably contributed to the survey's results. There are several instances in which somebody wrote "ojo" (attention) next to particularly suspicious claims, many farmers didn't have shares to the comunidades de aguas, and the groundwater boom was just beginning.

The Cabildo Insular and the ayuntamientos tried to redistribute water by encouraging relatively wealthy water owners to sell water to needy farmers at a price the Civil Governor set. The Alcalde of Firgas purchased water from members of the Heredad de San Andrés in 1942 (Ayuntamiento de Firgas, 1942). The Local Irrigation Commission in Arucas encouraged members of the Heredad to sell their water in 1943. It also requested that the Comunidad de Quintanilla y de Lentisco elevate water from the Barranco de Tenoya to Arucas and sell it for the cost of production and transportation. The commission also instructed farmers submit formal complaints about vendors who denied them water. Retired farmers from Arucas and Firgas tell me that the efforts to control the water markets were ineffective. Relatively little water was ever redistributed and price caps could be circumvented illegally by reducing the amount of water sent to the consumer.

The Intensification of Groundwater Mining

Peace and Europe's reconstruction reinvigorated the archipelago's agricultural markets, enlarged the capital stocks that investors needed to open wells, and unleashed unprecedented numbers of claims to groundwater. National officials were keenly aware that the economic development of the Canary Islands depended on the success of its unique water management practices and property regimes. As it reorganized its national water administrations in 1947 (Guimera Peraza 1968: 17), it formed two new hydrological services to represent the provinces of Santa Cruz and Las Palmas and extended the archipelago's political authorities great latitude to formulate their own water law, regulations, and policies. Both organizations were immediately besieged by investors seeking mining concessions. Approximately 20% of all of the concessions to groundwater mining were issued in a 3 year period; the Hydrological Service in Las Palmas granted 1,918 authorizations between 1947 and 1950. It granted 1,062 concessions in 1947 alone (Cabrera Hidalgo 1970).

The comunidades de aguas and heredades spent years literally undermining each other. Pozeros deepened pozos, extended galerías, and drilled sondeos and catas without either the mining rights of those who owned the land above the mines or the state's authorization. The investors knew they were competing with each other because they ordered the pozeros to drill towards the areas that proved productive for each other. In many cases the pozeros who extended one mineshaft would open its rival too. Those who were threatened by new boreholes filed complaints if they could be confident that their own activities would not be brought into question. They didn't complain often. Public officials estimate that over 90% of the subterranean facilities had been modified illegally. Government engineers didn't bother reporting illegal waterworks because they understood that everybody needed water and the laws regulating the industry were inadequate. Illegal mining was the most widely known and best kept secrete on the island.

The scope of the proposed projects grew enormously in response to the increased pressure on the acquifer and the inability to prevent competitors from opening nearby mineshafts. Only the largest associations and wealthiest individuals could afford these massive projects. For example, in 1951 the Heredad de Arucas y Firgas proposed to construct 22 pozos with inter-connecting galerías. The pozos were to be constructed on 17 sites on public and private lands throughout the Barranco de la Virgen, Casarón, Troyanas and Carpinteras in the jurisdictions of Firgas, Moya, and Valleseco (Jefatura de Obras Públicas y Minas exp. 273.269 CP, 1950). The project could have easily drained the entire region. In all likelihood, most of the pozos were protective in nature and only a few mineshafts would have been constructed. Although the project was not authorized as a package, the heredad managed to construct several of the pozos several years later.

Projects like these represented grave threats to competitors. Even the Heredad de Arucas y Firgas' representative, Don Jon García Días, objected to the proliferation of mineshafts:

> The day that they perforate all of these pozos and galerías the springs will be affected and on this day, it will be impossible to determine who is at fault.[10]

He reaffirmed what had been obvious to everyone since the 1870's and had been proven repeatedly in decades of legal battles. People who lost their springs rarely claimed the deposits that government officials required investors make as a form of liability insurance because hydro-geologists could not readily prove that any two sources were linked. Although any pozero with experience could tell you exactly which direction the water flowed into any of the mineshafts, and had established some mental map of how the subterranean rivers ran, he was hardly in the position to act as an impartial witness. Furthermore, there was seldom any great need to testify because waterless individuals couldn't raise enough funds to hire lawyers and spend years in court trying to prove that a specific source damaged their own.

The state did make it more difficult to acquire an authorization with the proclamation of the Special Water Law for The Canary Islands in 1962. The law was largely ineffective because the entire region had already been saturated with claims so that the application rate for new mineshafts had already fallen (Cabrera Hidalgo 1970; Brier y Bravo de la Laguna 1981). Meanwhile, the new Hydrological Services failed to establish regulatory control over the existing mine shafts because they lacked enough agents to effectively monitor and regulate the competing water users groups. The laws concerning the right to extend or add shafts were debated, modified, used when they served ones' own interests, and ignored when they did not. The market was clearly more influential than the state's pressure or the law itself.

As such, I think that Don Correa Viera, the illustrious notary public from Arucas who worked with the water users associations throughout the archipelago, was wrong when he summed up the situation in a lecture to water managers in the Spanish peninsula by saying,

> Today, our production is charged by urgent demands to capture water and it doesn't occur to people to think of the well-being that a total solution to our hydrological problem would bring to us.[11]

I've met plenty of elderly people who thought about their water problems every day of their adult lives but could not solve them in a way that would satisfy everybody. Nobody doubts that, in an ideal situation, investors could have drilled fewer wells and extracted the same amount of water for less money. The optimal rate was unattainable because the shear complexity of the island's hydrogeology, the highly fractured land tenure system, and the competing economic interests made the potential wealth for the few who might capture it too attractive for anybody to cooperate extensively.

None of the potential solutions would benefit everybody. The most powerful participants came up with a solution that served them very well; they intensified their mining activities. Speculators and coastal farmers who owned water profited from their water sales and agricultural investments. Those who purchased water could profit on the agricultural market as long as international competition was minimal and the wholesale prices were generous. The state benefitted because it helped the private sector increase agricultural production to feed a rapidly urbanizing society and collected taxes. Poor farmers and ayuntamientos struggled to protect their water rights, but the best they could do was to make deals with comunidades de aguas for mining rights or buy water from them

Requiem for the Heredades

Groundwater mining destroyed most of the heredades and made farmers and the ayuntamientos dependent on the comunidades de aguas. Don Juan Ramos, a well-respected hydraulic engineer from Moya who worked with the Heredad de Arucas y Firgas among other heredades, captured the situation perfectly as it existed in the mid-1950s;

> ..the heredades on Gran Canaria will continue to die along the road already begun. It will only be a question of time; but what is certain is that they still live and deserve to continue living because the pseudo-heredades formed mostly by non-farmers cannot take their place. The water societies create an illusion, but annihilate the laborers: what interests them is that many laborers don't have water so that they can pay a good price for that which is indispensable, because the elevated price climbs by the demand for it, and so will have to depend on their earnings.[12]

All of the heredades registered in Valleseco, Firgas, Teror, and Valleseco saw their springs go dry. Heredades and comunidades de regantes that captured surface water were not destroyed, although their importance declined. For example, the Heredad de los Granados, which captures water in the Barranco de los Granados and transports water from the Acequia de San Juan to the Acequia de Cardones, still enjoys priority use of the acequia. Its members can interrupt the transport of water from any other source whenever it rains so they can capture the rainwater flowing into the acequia.

The Water Law of 1956

The Water Law of 1956 is the great irony of the era because it legitimated the co-existence of many different kinds of water users associations while they all were undergoing a tumultuous process of convergent evolution that defied legal codes. Until its passage, the leadership of heredades could not legally represent or act for the collection of members because the heredades were not jural institutions that stood independently from their members. Of course, the leadership in large heredades represented and acted for the members every day The gap between their formal legal status and practice invited disaster. Recall that the Heredad de Tenoya lost a large portion of its members' water in 1878.

A dispute between the Ayuntamiento of Arucas and the Heredad de Arucas y Firgas signaled a sea change in the legal status of the indigenous water users' groups. In its effort to secure water for public consumption in the late 1930s, Arucas purchased shares to the Heredamiento del Molino, which the Heredad de Arucas y Firgas administered. The ayuntamiento tried to force the heredad to allocate all of the heredamiento's water to satisfy the public's demand. The heredad objected. It claimed that the water was private property and it had to manage the water according to its own time-honored administrative rules, not according to the ayuntamiento's commands.

Their fascinating dispute, which deserves far more attention than I can devote here, reached the Spanish Supreme Court in 1954 (Pérez Afonso 1968). The court ruled that the ayuntamiento had to buy the heredamiento's water at its market value. More importantly, the court reexamined the status of the Heredad de Arucas y Firgas itself. The state challenged the claim that heredades were groups of individual property owners that provided a critical social service and declared it to be a *comunidad de bienes*, that is, a group of individuals united to produce and profit from an activity. As such, the heredad could stand apart from its members, its leadership could to act with some autonomy, and the members could possibly be taxed if they sold water.

The decision revived the perennial question about the legal property and administrative status of all water users groups. Scholars presented competing theories. Under Spanish law, these groups could either be defined as institutions, corporations, civil associations or individuals, societies, Roman communities (classic common property), non-Roman communities (private property administered collectively), or a mixture of these types (Ramírez Suárez 1962: 34-ff). The key factors distinguishing the groups were: the nature of the water source, the time the property was first allocated; the nature of the title holder and the managerial body; and the ends to which the waters were put.

While scholars struggled to identify the legal status of the wide variety of water management institutions that existed through out the archipelago, their members and farmers saw them undergo a process of convergent evolution. Not only did they operate in ways that were fairly independent of their formal legal distinctions, most of the organizations mined water or disappeared, tied proportional voting rights to property holdings, and sold both shares and water on the market independent of land transactions. The blurring reached the point where members considered heredades, comunidades de aguas, and comunidades de regantes to largely be the same things. Even the names of the institutions became ambiguous. For example, the Heredad El Pinillo merged with the Comunidad de La Pila and changed its name to the Heredad de Regantes de "El Pinillo" y de "La Pila". The owners of a pozo called their organization the Comunidad de Regantes La Guancha. The Heredad de Arucas y Firgas was sometimes referred to as the Heredad de Aguas de Arucas y Firgas.

The Water Law of 1956 alleviated the institutional identity crisis by recognizing the jural co-existence of heredades, heredamientos, comunidades de regantes, comunidades de aguas, sub-acequias, and other kinds of water users groups. All of the organizations were ordered to provide the state with documentary proof of their existence and a description of their organization and capital. Many of the existing organizations had to modify their statutes, if not their activities.

One of the basic lessons of the Water Law of 1956 was that the shifting water technology and economic opportunities that emerged in the late 19th century selected against long established proprietary rights to surface water. The government did not have to nullify existing rights; the very shift in the means of production would rendered them inconsequential.

Summary

It should be clear that the strong agricultural markets sponsored a shift in water technology and the location of water production. These changes brought the property regimes established by heredades, comunidades de regantes, and ayuntamientos into conflict. The demand for larger supplies of water were so intense that people contributed to the destruction of their own water users associations and extended families The rise of the new property regime occurred despite nominal legal support of the state to protect existing property regimes because the most powerful groups and state benefitted from the intensification of agriculture and industries.

Notes

1. La riqueza más sólida de Canarias es la líquida (García Lorenzana quoted in Pérez Afonso 1974: 16).

2.

One example should suffice to show how much the motors are coveted. The President of a well known heredad and I went to one of its unproductive pozos to see its mint condition Blackstone-Liston engine. The pozo was located in a small horseshoe valley which most farmers had stopped cultivating in the 1980's. To get to it we had to use long sticks to slowly open a tunnel through a forest of thickets and barbed vines blocking a steep and winding path. We cleared away a wall of thickets, pushed the pozo's rotting door open, and squeezed through. Large sections of the ceramic roof had long since caved in and thickets dangled from the walls and ceiling struts. The President slowly walked towards the back of the pozo dumfounded to find that the motor was gone. Thieves must have lifted the 2 ton motor from its mooring, through the roof, and up the hillsides before carting it away. Both of us were genuinely impressed by the amount of work the thieves must have done to get their prize. The engine is probably working in a more profitable pozo somewhere on the island. Thefts of this kind are not rare because the motors are impossible to get on the market.

3. The colloquial phrase for this is 'metirse la mano en la jarra del gofio'.

4.

El gravísimo peligro de captura y destraer el todo o parte por lo menos de esas aguas de los manantiales del rapador y de las madres, pertencentes a la heredad, encontrándose el mencionado ultimamente que es el más distante, a unos tres kilómetros del indicado pozo proyectado. La configuración de suelos y subsuelos en aquella zona pone de manifiesto aún a los ojos del más profano, que esta peligro inverato por la heredad de mi Presidencia, no es una cosa imaginaria o ilusoria, sino una realidad manifiesto y tangible.

5.

Lo probable es que a dicha distancia las obras proyectadas no afectan al mencionado manantial, pero dada la importancia de éste [Las Madres], y la imposibilidad de asegurar que las galerías no cortarán algunos de los venos que lo alimentan, parece prudente autorizar de momento sólo el pozo, que tiene ya un radio de influencia mucho menor (expediente 1034).

6.

Por nuestra parte replicamos que si la ley presume, como hace contestar el opositor un presunción juris et de jur, que dentro de las 100 metros hay peligro cierto, la propia ley presume, juris et de jure, igualmente que fuera de las 100 metros desaparece la seguridad del peligro.

7. Éste es uno de los muchos proyectos absurdos que a veces solicitan algunas heredades, quizá no con ánimo de ejecutarlos, sino de impedir que otros vengan a explotar aguas en los barrancos que ellas consideran como su exclusiva propiedad (Ingeniero Jefe: Dec. 13, 1943; exp. 1381).

8. Residents in Lanzarote, Valleseco celebrated the first annual Traida del Tabique in the Fiesta de Santa Rosa de Lima while I lived there in August, 1994. The participants of the search traveled about 5 km to the Cruce de Corcho where many herders grazed goats. After the Plate River Band from Moya played several marching tunes, hundreds of celebrants slowly walked, talked, danced, sang, laughed, ran and drank their way back to Lanzarote. Along the way, some men offered tabique from the large milk containers that they carried to all of the passengers in cars that crept by the procession. I must confess that there was more far more rum (Ron Ahrucas), which the celebrants called tabique amarillo (yellow tabique), than regular tabique. The fun belied a much more serious intent; the organizers wanted to teach the younger generation about life in Valleseco before supermarkets.

9. Para confeccionar un estudio que facilitará una fórmula viable que resuelva el problema planteado por la escasez de agua con destino a la agricultura, cuya sequia traería consigo no solo

un grave quebranto para la economía insular, sino además un serio problema que repercutiría en el abstecimiento en general, si la tierra dejaría de producir por falta del agua necesaria.

10. El día en que se perforen todos esos pozos y galerías, los manantiales serán afectados y ese día será imposible averiguar de quien es la "culpa" (exp. 1450).

11. Hoy por hoy, nuestras producciones están recargadas con las exigencias de la obtención del líquido y a nadie se le ocurre pensar en el bienestar que nos traería una solución total de nuestro problema hidráulico. (Correa Viera quoted in Guimera Peraza 1968: 16)

12. Por el camino emprendido irán muriendo las Heredades de aguas de Gran Canaria: Será sólo cuestión de tiempo; pero lo cierto es que todavía viven y merecen seguir viviendo, porque no pueden ocupar su puesto las pseudo-Heredades formadas por socios que no son agricultores, en su mayoría. Las sociedades de aguas cifran su ilusión en lo contrario de lo que anhelan los labradores: para ellas lo interestante es que muchos labradores no tengan agua, para que paguen a buen precio la que les es indispensable, porque del elevado precio que alcance por la demanda que de ella existe, habrá de depender su ganancia (Ramos 1954: 64).

CHAPTER 5
WATER DISTRIBUTION DURING THE GROUNDWATER ERA

A fundamental change in the property regime governing water distribution accompanied the intensification of surface water capture and the shift to groundwater mining. Investments in storage, measurement, and distribution technology made it both possible and profitable for the landed gentry, entrepreneurs, and water users associations to seal off public access to water. The intense demand for water and private nature of the water distribution system fostered the rise of a corrupt, but adaptive, market system. Extortion and theft increased the average cost of water put to use by its consumers but also increased the number of farmers who could acquire it.

The Creation of A New Water Distribution Network

As capital began pouring in from the banana market, major water users associations like the Heredad del Cumbre and the Heredad Cortijo del Crespo were joined by a growing number of individual landowners who sought ways to reduce their conveyance loses. The conveyance losses were caused by evaporation, infiltration, and legal and illegal withdrawls by people along their acequias. The water owners could eliminate a significant proportion of their conveyance loses by acquiring more impermeable construction materials and sealing their acequias.

The number of proposed transportation projects increased during the first part of the 20th century and water distribution became temporarily less centralized. The water owners' ability to shut out public access to water was checked only briefly by statutes in the Water Laws of 1866 and 1879 and the Ordenanzas del Melgarejo. Water owners or proprietors who could not seal their acequias began installing cement and iron subterranean piping through private and public lands. Landowners often received a portion of the water flowing through the pipes, charged a right-of-way fee, or demanded the right to purchase water at discounts. Anyone who laid pipes through public lands had to pay a special tax for occupation of the state subsoil. By 1936, Valleseco imposed 37 sub-soil taxes on individuals as well as heredamientos and heredades (Ayuntamiento de Valleseco, 1936: exp. 11(26). The number rose to 45 by 1943 (Ayuntamiento de Valleseco, 1943: exp. 90(126)). The same is probably true for Arucas and Firgas but I could not locate the necessary records to test this hypothesis. Part of the reason for the jump in the number of acequias and pipes was that groundwater mining at pozos and galerias were not only destroying springs, they were creating new sources that required a new integrated distribution system.

Although you might expect the rise of new water transportation lines would decentralize control over the water supplies, power became even more concentrated for several reasons. First, most farmers could muster only enough money for relatively short pipelines that brought water from nearby cantoneras to their farms. Second, the heredades and comunidades de aguas usually could not raise enough capital to build long pipelines or acequias aside from their mineshafts because they risked all they had on the mines. Third, it made absolutely no sense to build hundreds of duplicate fairly fragile concrete pipelines that would eventually cross over and crush each other on the island's steep embankments. The situation was ripe for entrepreneurs to create a unifying web of pipes and canals to link the new water sources with the old sub-acequias and to many new private distribution works.

The entrepreneurs who built the distribution system immediately acquired an enormous amount of power. Once they controlled the pipes, they could also charge fees and buy and sell water. Vendors are normally referred to as called *rancheros*, *redistributadores* or *vendedores*. But whenever Canary Islanders are angry and out of earshot of the vendors, they use the terms *aguatenientes* (water owners) and *aguamagnates* (water magnates). *Aguateniente* connotes a ruthless water owner or vendor who lies, steals, cheats, bullies, and extorts. Canary Islanders insist that a tiny class of vendors, speculators, and administrators formed a cartel or mafia that regulated water production and distribution.

Of all of the vendors, Don Pedro Morales Deniz was the perhaps the most legendary on Gran Canaria. His amazing 50 year long career began as a peon who laid pipelines for an absentee speculator. He assumed control over the business when his boss left for the Caribbean in the 1930s He and his employees laid 124 km of pipe through Valleseco, Firgas, Moya, Teror, and Arucas over the course over the following 40 years. He purchased shares in over 67 comunidades de aguas, heredades, comunidades de regantes so he could participate in their management and secure the first opportunity to purchase water should a member decide to sell it. He also held shares in 30 comunidades that operated tanks through out the region. Don Pedro employed as many as 70 construction workers, accountants, saltadores (tank operators), and acquieros at the height of his powers in the 1950's and 1960's. Local acequieros estimate that he controlled as much as 40% of the water produced in the region. Nearly 20 years after his death, his initials, PMD, still mark pozos, valve and equipment housings, and tanks through out the region. His empire crumbled after his death, partly because many of the pozos and galerias became unprofitable, partly because his distribution network reached the end of its life span, and partly because his two sons were not equal to the task before them and died shortly after assuming control over their troubled business. Their own heirs have just a few employees and are trying to pay off monumental debts. Now it is not uncommon for strangers to publically ridicule the young descendants of Don Pedro for alleged activities that have neither been brought before the courts nor that they participated in.

Don Pedro was not alone. It was an age of speculation. Nearly everybody sold water on some occasion. But only a relative few made their living by marketing and distributing water Other famous vendors such as Aniceto and Juan Falcón, Pedro Rosales, the Schumann family whom people called

Los Alemanes (the Germans), the Blandy Brothers, Flietas, González, and Guerra. The most established families such as the Massieu and Manrique de Lara sold water too. Acequieros estimate that PMD and Juan Falcón controlled about 80% of the water in the region between the 1940's to the 1970's. Juan Falcón administered several comunidades de aguas and heredades, including the Heredad de Arucas y Firgas during the 1950's.

The Distribution System

The distribution system constructed during the era of groundwater mining is composed of water sources, conveyance networks, and holding tanks. By the 1950's the newer conveyance network enveloped the older systems (Figure 5-1). The acequias and pipes connected at several hundred mineshafts stretching from Santa Brigida to Moya with the sub-acequias built by the Heredad de Arucas y Firgas, Comunidad de Regantes de Tenoya, Heredad de San Andrés, and the Heredad del Pinillo. The conveyance system is so intricate that it is virtually impossible to stand on any hill in Valleseco, Firgas, Teror, and Arucas without seeing a canal or pipe; if there is no acequia at your feet, then there is one in the distance.

The region seems like a museum of water conveyance technology. Few of the wooden acequias survive but stone acequias that were cut into natural deposits lay next to stone and cement acequias as well as iron, aluminum, plastic, and rubber pipes. Many of the stone acequias were built during this century. Laborers hollowed out blue phonolitic stone to build canals measuring up to a square meter in area. Each stonecutter produce enough to lay 30 meters of canal a day. They built at least a thousand kilometers of canals island wide. Some monumental aqueducts hug cliffs and pass over valleys. One aqueduct built in Bañaderos about a century ago is connected to other acequias and remains level enough to transport water from either direction.

There are a few locations that stand out from the thousands of sites where canals and pipes

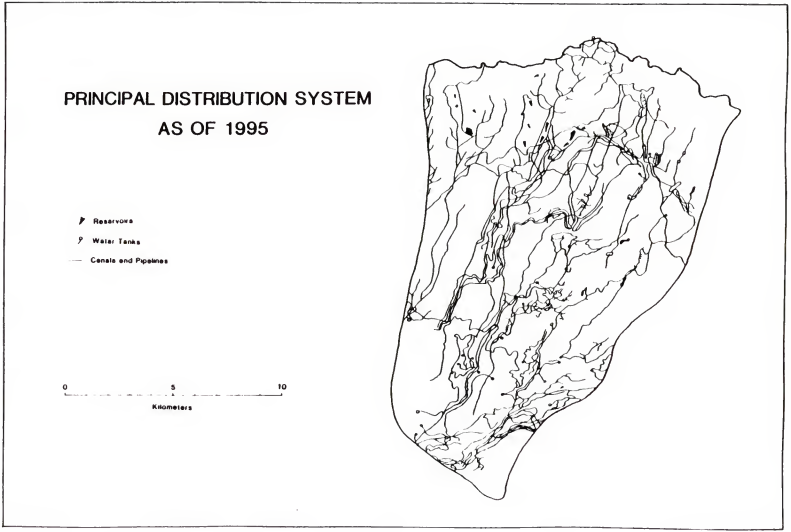


Figure 5-1 Principal Distribution System as of 1993

unite with cantoneras and water tanks. One of the most important is at Los Rosales, Firgas where Don Pedro Morales Deniz built two large regulating tanks and two cubical cantoneras next to the Heredad de Arucas y Firgas' principal canal and the Comunidad de Regantes del Cumbre's cantonera. The amount of water passing through the region was so great that Deniz set one cantonera on the roof of the housing for the second cantonera. The water flowing from the second cantonera was measured by both the standard measurement system and by a limnigraphic meter before passing to 8 private distribution works owned by local farmers.

Another key distribution point is in front of the Heredad de Arucas y Firgas' administrative building in Arucas. Comunidades de aguas owned by the Blandy Brothers and other wealthy investors built two ornate fountains that serve as cantoneras near the heredad's last major cantonera. Water flows into the Fuente de Claret, wells up to the top, spills out of four rectangular holes into four secondary basins, and into eight tertiary basins before passing into pipes that connect to the sub-acequias El Alta and San Juan. Currently, water flows through only one quarter of the Fuente because most of the water sources are no longer in regular service. The other fountain, whose name nobody could tell me, is less ornate and no longer transports much water.

El Molino is located at the base of Montaña Arucas in Transmontaña and is surrounded by at least 20 large stone and cement tanks less than one kilometer in any direction. Its name refers to a molino that formed part of the distribution network. Water from the heredad, PMD, and many other sources flowed through a complex maze of cantoneras into two tertiary canals of the Sub-Acequia El Alta. From there the Cardones and Guincho tributaries carry water to some of the most valuable agricultural lands in Arucas. As of today, El Molino, just like hundreds of other distribution points, is largely abandoned. The Heredad de Arucas y Firgas' still has a cantonera that distributes water from the Pinto dams next to the sub-acequia's regular cantonera. The maze of cantoneras next to them are owned by PMD, El Porrón or La Quintanilla, among others. PMD purchased and operated a huge square cantonera that passed water up from its center and through 60 bocas. This cantonera, like most of the others, fell out of use in the 1980s.

The last key point I will mention is located just below Montaña Arucas in the Barranco de Arucas. The Sub-Acequia de San Juan meets with the Comunidad de Santa Brigida and PMD and diverts water through the Acequia de los Granados to the Sub-Acequia de Cardones, which formed to irrigate land around Montaña Cardones. Several large cantoneras are located on platforms above others that rest on the ground. Again, the amount of water flowing through these cantoneras has dwindled over the past twenty years.

Sub-Acequias in the Era of Groundwater

During the heyday of groundwater mining, the five major sub-acequias of the Heredad de Arucas y Firgas and the Sub-Acequia in Cardones assumed an even greater independence because they transported water from almost any source in the region. They charged cuotas based on the amount of land and kind of crops under cultivation and imposed derramas on the amount of water transported. Since they had no specific source of water, but rather transported water from many heredades and comunidades de aguas, the sub-acequias did not establish dulas. Instead the members worked with the vendors, acequieros, salteros, and neighbors to schedule water deliveries. The acequieros negotiated water transfers and, when necessary, tested water before purchasing it or letting it flow through the acequias.

Since the sub-acequias' ability to function was closely linked to the distribution of land, it was sensitive to differences in voting power. Some of the wealthiest residents, like the Marquesa de Arucas, built their own hydraulic networks to avoid interference from middlemen. They retained their membership in the sub-acequias because they were still landholders in the area, and as such, remained extremely influential in the decision making process. This hindered the sub-acequias because without the support of the wealthiest members, the others farmers might not be able to afford capital investments or make administrative adjustments.

In addition, groups of farmers or relatively prosperous farmers laid their own pipelines to take water from the sub-acequias or near by mineshafts. The practice of partible inheritance increased he number of people who hold rights to these minor systems. These tertiary canal and pipe systems are operated like the sub-acequias. Individuals holding rights to these transportation systems established Members established rules governing the right of way to regulate water transportation. They formed rules stating the kind of water that can be passed on given days. Anybody who has the right to use the system may empty the pipeline if another person is transporting their water in a way that violates the norms of their association. Unfortunately, there is almost no systematic treatment of these associations. They seldom appear on public lists and often lack stable names.

Distributing Water

One of the unintended consequences of relying on distribution systems that were not owned by the main producers and consumers was that everybody lost managerial control to the vendors and their poorly-paid laborers. A small army of laborers guided water from the highlands to lowland farms and municipal deposits when the groundwater boom was at its zenith during the 1960's. Since over 200 water sources were capable of producing more water than the distribution systems could possibly handle, the saltadores and acequieros who operated the pozos, galerias, tanks, and pipelines told the comunidades de aguas when and where they could transport water.

The process of distributing water along the sub-acequias has not changed very much since the 1950s. Vendors still gather at 6 AM Monday through Saturday at the Heredad de Arucas y Firgas to distribute delivery sheets to the acequieros. The sheets itemize the total amount of water to be distributed, its price, the size of the azada, the amounts going to each recipient, the cantoneras water should be sent to, the time of the day it should be sent, and include other relevant observations such as payment schedules and water quality

Since the water quality from the different sources is bound to vary, the acequieros have to be careful. They estimate salinity levels by either using a calibrated meter or by throwing a wadded piece of paper into a standing pool of water; if the paper rides on top of the water, its salinity is too high to irrigate banana Acequieros send all of the water through the conveyance network if there is no appreciable chemical difference *Agua mala* (bad water) can only be distributed either when the sub-acequias are not distributing *agua buena* or on Thursday Sometimes vendors and farmers mix different kinds of water in the sub-acequias as it flows to their owners.

Acequieros keep track of the water they distribute by adding and subtracting the amount of water they divert in each cantonera as they travel from the upper to lower part of the canal system. The system is so complex and so large that no matter how skilled the acequieros were, they spent the day running back and forth between cantoneras and tanks to regulate the rate and direction of water flow As you might expect, the physical exertion and emphasis on time that their work required made all of the retired acequieros I know so extremely punctual that they habitually look at their watches several times during the course of an informal conversation and a couple are so healthy that they scramble up steep hills.

The Water Market in Arucas

The largest water markets on Gran Canaria operated in Gáldar-Guía, Arucas, San Mateo, Telde, and Sardina del Sur The heart of the water market in Arucas was located in front of the Heredad de Arucas y Firgas' administrative building The location was perfect. The heredad the dominant association in the region. More over, several comunidades de aguas built their cantoneras there so they could distribute water to the Sub-Acequias El Alta and San Juan, and the area is less than

300 meters from the ayuntamiento, the municipal markets, and banks. Plus, the new network of paved roads made it relatively easy to travel anywhere in the region. Not surprisingly, it is still a great meeting place for farmers who come into town to conduct business or just to visit friends.

Since the heredad was not technically an independent organization and could not own water, it could not sell it either. But its administrators could facilitate transactions between members and vendors and regular buyers. In those cases where the owners left no instructions, the water was automatically sold on their behalf to vendors. Since, most of the heredad's members own small shares of water and no longer farm, many formed long-term agreements with vendors who automatically purchase their water. At the end of each dula, administrators and vendors clear their accounts. Several farmers estimate that as much as one-third of the heredad's water is distributed this way today.

The heredad was so important that it set the daily market price of water for most of the comunidades de aguas just by setting its own price. The heredad's administrators calculated the price they would ask for any member who wished to sell his or her own water. The price covered the cost of production and included a sizable profit rate. Since the size and the price of an azada were pegged to the water supply, both fluctuated on a daily basis until the 1970's when the Heredad de Arucas y Firgas began to stabilize its prices by setting them for extended periods. Its administrators posted the size of an azada and its daily price on a board located just inside its great wooden doors. They stopped the practice in the 1980's when a series of drug-related thefts forced the heredad to seal its doors during business hours. Now to enter the heredad one must knock on a wooden panel underneath the main office window. The administrator in charge will come to the window, inquire about your business, and decide whether or not to let you in.

The second unintended consequence of the separation of property rights between the production and distribution technology is that the vendors and acequieros gained almost total control over the water markets. Vendors knew how much water was produced on any given day, who held rights in each association, and who needed to irrigate crops. They exchanged orders, transported water, collected payments, tips, and kept profits.

Just as importantly, the acequieros had every reason to become vendors themselves. Many of the acequieros were relatively poor men who often inherited their jobs from their fathers. They worked between 12 to 16 hours per day, Monday through Saturday, except on important fiestas. These long hours reflect the time it takes for water to travel through the entire irrigation network. Acequieros and salteros were paid to work 8 hours a day and received some benefits from their employers and the state, but they could certainly earn more by selling water too. Therefore, many of the acequieros became middlemen and took orders they would pass on to their employers. Thus, consumers often had to pay at *least* two middlemen to get water.

The conflict of interests between water owners, vendors, acequieros, government officials, and farmers became increasingly counterproductive. Acequieros who worked for vendors were sometimes commanded to turn over their profits or risk being fired. I have heard of only one case where the acequiero flatly refused; the employer backed down because the acequiero was the only one who knew the clients and how his section of the distribution network operated. Other acequieros reportedly stole water from the vendors and sold it on their own. Legend has it that the first thing one of Don Pedro Morales' sons did when he gained control over the family business was to march his four bookkeepers down to the police station where he had them arrested for theft.

Conflicts like these make discussing water prices and sales patterns extremely difficult. Detailed records of market prices are very hard to obtain. Vendors have the best records but have little incentive to release them. The information I managed to collect is terribly spotty and must not be considered as the final authoritative database. This disclaimer aside, I must say that the data tend to support claims made by vendors, farmers, ayuntamientos, and scholars who had access to more complete information.

A three tiered pricing system evolved. In the cheapest tier, members of comunidades de aguas and heredades received, traded, and/or sold water among themselves at prices they established. They had to pay an extra *cañon* if they used somebody else's distribution network. The two more expensive tiers were for farmers and ayuntamientos who purchased water on the open market. Vendors say that ayuntamientos usually pay about 20% more than farmers. This accords well with the data I've collected for prices paid by ayuntamientos and farmers for the years, 1970-1974, and 1993. In 1970, the ayuntamientos paid 80 psts/m^3 while farmers paid 57 pts/m^3 (1990 psts). In 1993, they ayuntamientos paid an average of 74.96 pts/m^3 (1990 psts) while farmers paid 59.03 pts/m^3. A Pearson's correlation test (r= -0.431) suggests that the price paid by farmers varied, to a limited extent, inversely with rainfall. The prices paid by the ayuntamientos did not correlate with rainfall (r=0.015) because they signed long-term contracts with vendors, making the prices more rigid. Of course, as I will explain in a moment, neither the ayuntamientos nor farmers could count on receiving the amount of water they paid for.

The Effect of Water Quality on the Water Market

By the 1970s, the deteriorating quality of water forced its price to vary widely. Vendors had to peg the price of water to both its production costs and quality. Farmers took advantage of the prices to search for good deals. One retired acequiero and farmer explained it to me this way. Imagine that a farmer needs 4 azadas of 25 mm to irrigate 20 *celemines* (or 1.74 ha) of banana. The market price for good highland water is 20,000 pts for an azada of 25 mm (166 m^3) but somebody offers saline water from a coastal pozo for 12,0000/azada/50 mm (354.16 m^3). The farmer could buy 4 azadas of good quality water for 80,000 pts. The better option is to buy 3 azadas of good water and 1 azada of saline water for 82,0000 pts. Here's how. He pays 40,000 pts for 2 azadas (332 m^3) of good highland water. That leaves him with 40,000 pts. Then he purchases one azada of saline water for 12,000 psts

Since 50 mm amounts to slightly more than twice the amount of water given in an azada of 25 mm, the farmer spends 62,000 pts for 686 32 m^3 instead of 80,000 pts for 664 32 m^3 At this point, the best thing he could do is spend another 20,000 psts to buy another azada of good water from somebody else. Thus, the farmer spends a total of 82,000 pts. for 856 m^3 of water and irrigates an additional 5 celemines (2,685 m^2) for 2,000 pts. more than he intended to spend. The danger is that the water quality is marginal; after all, 41% of the water was saline enough to warrant a special price. Enough farmers have seen their neighbors destroy their fields by using saline water to be wary of this tactic. Now that desalinated and treated waste water is becoming available farmers have to pay closer attention to market prices and water quality just to continue farming.

How Vendors Cheat Water Owners

Everybody in the Canary Islands complains about the manipulation of the market by owners, vendors, and acequieros. They bitterly criticize the government for remaining passive, if not tacitly supporting the exploitation. A few insist that current shortages are artificial; water owners are not pumping it to the surface because they can't make a profit when tight agricultural wholesale markets make it difficult for farmers to absorb the cost of water. Furthermore, some owners are purchasing mineshafts around their own as a protective measure. While I have no doubt that water is withheld to boost prices, there are far more creative ways to exploit both water owners and customers.

Consider the following scenario. A member of a comunidad de agua owns 1 azada of 25 mm or 166 m^3. Assume that it costs 4,000 pts or 24 pts/m^3 to produce. If the owner is lucky, he can have the vendor transport the water for a simple transportation fee. But, since the vendor owns and/or operates the only transportation system available, he can force the owner to sell the water on his own terms. Lets suppose that the vendor purchases water from a member of a comunidad de aguas. The vendor can argue that 2 mm of the azada (12.38 m^3 or 7.4% of the total amount) would be lost before it reached his tank, and so pays for only 23 mm or 153.6 m^3 to offset any possible loses. However, the vendor may not loose any water at all if there is a tank nearby. Therefore, the initial owner receives 3,686 pts (24 pts/m^3 * 153.6 m^3) for the water and loses 2 mm (valued at 314 pts) to the vendor. Now, suppose that the original owner wishes to purchase the water and have it transported to his/her farm. Since the customer is also a comunero, the vendor may sell the azada of 25 mm for 6,000 pts or 36.14 pts/m^3. This time the vendor does not adjust for the 2 mm of water that *will* be lost during conveyance. Thus, the original owner purchases a nominal amount of 25 mm or 166 m^3, but receives 23 mm or 153.6 m^3. The vendor also charges 300 pts to transport the water. To sum up, the original owner first loses 314 pts to the vendor and then pays 6,300 pts to receive 153.6 m^3 water. Instead of paying 24 pts/m^3, the original owner pays (6,300 + 314/153.6 m^3) 43 pts/m^3 for the water that makes it to the farm.

Vendors have a much simpler way to extract rents. They demand a tip before selling any water. They may even require tips to sell a person the water that they themselves sold to the vendors. Continuing with the example, a vendor who demands a tip of 3,000 pts just to sell one azada increases the price another 18 pts/m^3 to 61 pts/m^3. Of course, the marginal increase declines as the number of azadas purchased increases. A customer who purchases 4 azadas pays an additional 4.5 pts/m^3 or a 47.5 pts/m^3 if the vendor demands a 3,000 pts tip. If a customer were charged the prevailing market rate, which surpassed 25,000 pts/azada during 1995, then the consumer would pay at least 28,300 pts for 153.6 m^3 for an average price of 184.24 pts/m^3.

How to Steal Water

Water theft is one of the first things that all farmers talk about. The cultural practice that makes theft possible is that water is sold from the point where it originates, not the point where the customer receives it. That way, one can always claim that conveyance losses are responsible for apparent losses.

There are several ways to steal water from the point where it is sold. Water can be stolen by partially closing a release valve and/or opening it when the volume of water in the tank, and hence, pressure is relatively low. Another option is to send water to several places simultaneously from the same source. That reduces the water pressure in the all of the outlets. All of these tactics reduce the flow rate, and thus the total amount received in the allotted time.

There are still more ways to intervene at the cantonera. One can reduce the volume passing through each boca by lowering the tablilla from, say, 25 mm to 23 mm. A wider tablilla or block can be used to reduce the size of the opening. The bocas can be opened before the water level rises to the upper edge of the tablilla so the water level will not rise high enough to generate the pressure needed to send the amount of purchased water through the cantonera. Similar results can be achieved by using a string to mark off the water level or by visually estimating the flow rate instead of using the tablilla. Conversely, the amount of time the boca is left open can be reduced. For example, one could let water pass through the cantonera for 100 minutes instead of 120 minutes. The 16% reduction in time means a 16% reduction in the amount of water that reaches the owner. Thus the consumer receives 139 5 m^3 instead of 166 m^3.

Another subtle way of stealing water is to give consumers cheaper, inferior quality water than they agreed to purchase. This option became fairly common in the 1970's when the coastal shafts produced increasingly saline water.

Riskier means can be adopted. Water can be diverted into a holding tank and the customer told that their acequias must be damaged. Pipeline owners sometimes steal water by intercepting it and claiming they hadn't given any permission to let the water pass through their property. Lastly, some people empty siphons and tanks.

Let me reiterate. There are many ways to steal water; these are only those I've learned about

Several acquaintances tell me there are still more ways I have not discovered, but have left these lessons for the future. All of these methods have one thing in common; water is purchased from the point where it leaves a tank, not where the consumer receives it. Farmers' requests to pay for only the water that reaches their tanks were repeatedly denied. Farmers receiving water have to be vigilant. They walk the length of their canal to watch the vendor, their assistants, and other consumers. But even these measures were frequently ineffective.

Do Not Call Your Vendor or Acequiero a Thief

Vendors are powerful people. They compete for customers but trade information about comunidades, government policies, consumers, and nosy social scientists. According to nearly all of the people I've spoken with, vendors used to blacklist farmers who complained about the quality, amount, or price of water they received. Vendors merely told the unfortunate farmers there was no water to sell.

I witnessed one person do exactly what every one tells me a farmer should never do. He confronted his vendor. Late during a July afternoon during the 1995 drought, a friend of mine told me that one of the water vendors I'd been wanting to meet was parked just a block away. I found him sitting in a four wheel drive truck on the shady side of the street. Three elderly farmers leaned against the wall of a house next to him. They were there to inquire about the water they contracted to buy 45 days earlier. The vendor had told them to wait a few days more; he didn't have any water

I asked the vendor if he sold much water in the area. He casually replied that farmers in the area usually traded water, they didn't buy much at all. I doubted that because nearly everybody in the area had already told me the exact opposite. I looked over to one of the farmers to see his reaction. He seemed dumfounded. He stared at me wide-eyed and opened his mouth but checked himself before saying anything.

Just at that moment, an acequiero quickly walked over and handed the vendor several orders. The vendor accepted them and opened a thick black leather bound book that recorded hundreds of old orders. I asked the acequiero if the farmers in the area traded most of their water. He immediately replied, "Very little, most buy it". The vendor winced, and then continued to arrange his papers. Muttering "communism...", he waved receipts that the government now requires him to give to his customers. Then he extracted a thick wad of money heavily sprinkled with large notes from an envelope, counted it, and added some notes.

Seconds later, a drunk middle aged man wearing a municipal work uniform parked his jeep on the far side of the street. He staggered over and asked why he had not received the water he ordered a month earlier. The vendor calmly explained that the drought created a great shortage, the other farmers surrounding him had been waiting for an even longer amount of time, and that he would deliver water as soon as he got some himself. Enraged, the farmer shot back by accusing the vendor of theft. The vendor repeated himself and quickly left.

As the other farmers dispersed, the acequiero invited the drunk farmer and myself to a nearby bar. The two talked over a beer and whiskey. They decided that the farmer should try a vendor who was more likely to have water. The acequiero's soothing and friendly advice seemed to calm the farmer down. But it didn't last. As soon as we stepped out of the bar he renewed his attack; "Thieves. Your and [the vendor] are thieves!". As the retired farmers who regularly loiter in the street turned to listen, the acequiero smiled painfully and explained, "He can say what he wants. The courts want proof and he doesn't have any."

To be fair, I am willing to bet that the vendor really did not have any water to sell at that moment. There was very little water on the market during the summer drought although many of the pozos that were normally unprofitable and unused had been brought back into service. The evidence was clear for anybody to see; the vendor's tank, like almost every other tank on the island, was virtually empty. More circumstantial evidence came three weeks later when the acequiero lost his own job because there was no water to distribute.

Nonetheless, the scenario conforms to the stories I've heard from angry and frustrated farmers, laborers, and public officials everywhere. They suspect the vendors and acequieros of theft and price manipulation but must be very slow to accuse them of specific acts. Only members of the upper class who are largely self-reliant can risk offending vendors. The rest are at their mercy.

Estimating the Relative Effects of Conveyance Loss and Theft

Farmers continually debate why they receive less water than they buy. A few farmers point out that they sometimes receive exactly what they purchased, sometimes more, but usually less. I've seen farmers glance at the water flowing through a cantonera and grumble "viene chica" (its coming short) because they were receiving less water than they should have, even after adjusting for conveyance loses.

This raises an important question. Just how much are the normal conveyance loses in the canals and pipes? Farmers in Valleseco estimate they loose about 10% (2.5 mm) in conveyance. Recent field studies by agricultural engineers estimate conveyance loses for the PMD network to be about 17%. The best estimates for conveyance loses along the coast come the Heredad de Arucas y Firgas and its sub-acequias. The heredad transports water from its albercón at Lomo Tomás de León about 6 kilometers to the cantonera Real in Arucas. Acequieros say it loses a minimum of 2 mm (8%) in the journey. Water flows from any of the heredad's cantoneras through secondary and tertiary canal systems. The sub-acequia de Casablanca serves about 100 members who irrigate a total of 100 hectares. They estimate their conveyance loses to be about 20% (Gobierno de Canarias 1995:97). Members of the sub-acequia de Rosales, Cambalud, Trapiche y Bañaderos irrigate about 1,200 hectares of the 3,000 hectares available to them. They also loose about 20% of their water (Gobierno de Canarias 1995:96). The sub-acequia de Las Vegas is the smallest; its 70 members estimate conveyance loses to be about 17% and have all but given up on agriculture (Gobierno de Canarias 1995: 97). Members of the Sub-Acequia El Alta, which serves 700 farmers and irrigates 350 hectares, estimate their conveyance loses rise to about 10% at Los Chorros and up to 30% near the coast. The averages the loses to be about 20% (Gobierno de Canarias 1995: 97). The Sub-Acequia de San Juan counts 150 members who cultivate 70 hectares. They estimated that the acequia lost about 15% of the 1,100 azadas distributed in 1994. The 239 farmers in Cardones who rely on their link with the San Juan estimate their conveyance loses to be between 8 to 10% (Gobierno de Canarias 1995:95).

One farmer who did take precise measurements calculated that he received 70% of the total volume of water that he either produced or purchased during a one year period. The conveyance loses of his acequia hovered around 10-15%. Thus the remaining 15-20% must have come from conveyance loses in other acequias and pipelines, mis-measurement, and/or theft. Acequieros blame leaky canals or a misunderstanding between the farmer and the vendors or original owners. Vendors blame the pipes, sub-acequias, and acequieros. Farmers are certain they loose about 10% of their water to theft. They search for vendors and acequieros they think will steal the least.

In all fairness to vendors and acequieros, if the average conveyance losses hover between 10 to 20% through out the network, then it is very possible that, in most cases, the difference between the amount customers purchase and what they receive can be attributed to conveyance loses alone. Other factors that might affect the distribution include slight differences in the flow of water through cantoneras, discrepancies in time allotments, etc...

None of this can be used to deny that theft did and does occur. The combined effects of conveyance losses, price manipulation, tipping, and theft increases the purchase cost of the water consumed. Anybody receiving 80% of the water they purchase for 100 pts/m^3 really pays an equivalent of 120 pts/m^3 for the water they do receive. In other words, farmers and ayuntamientos were paying two to three times the cost of production for the water they consumed.

Although every farmer I've met complains about theft, I must point out that many who did not have sufficient supplies benefitted from it. Water theft made it possible to acquire water in a market where demand was much higher than supply and the concentration of property was high. They may have received less than they wanted and paid relatively more for what they got, but they did get water The prices they paid were manageable as long as the wholesale market prices for their agricultural produce were large enough to ensure them a profit.

Summary

The change in the location of water production, the island's complex topography which made duplicate pipelines uneconomical, and the high production and operation costs associated with opening mineshafts created the opportunity for entrepreneurs to build and control private distribution networks. The highly competitive market and the ample opportunity for corruption created by the physical nature of the distribution network itself lead to relatively high conveyance losses, extortion, and theft. As long as farmers had access to chemically adequate water and could count on good international wholesale prices for their products, they could survive the water market itself.

CHAPTER 6

THE SOCIOECONOMIC CONSEQUENCES OF AQUIFER OVERDRAFT, TOURISM, AND URBANIZATION UNDER THE PRIVATE WATER PROPERTY REGIME

If you will recall, my general model posits that external market opportunities and techno-environmental circumstances on Gran Canaria have repeatedly initiated a series of occupational and demographic changes which lead to the rise and demise of the water property regimes. The model also admits that the property regimes themselves generated additional production and transaction costs, and thus influenced the profitability of competing economic activities. The Canary Islanders will only make capital investments as long as they can benefit from them under any property regime. New conditions create new conflicts and cause substantive changes in the distribution of property and the property regimes themselves.

The property regimes that operated during the 20th century altered the costs and benefits of allocating water among competing ends and users. Indeed, the costs arising from the private property regimes joined other factors that transformed the entire society. I argue that groundwater overdraft caused the water table to descend. This in turn, required additional investments to extend the shafts. The only reason the prices didn't increase in real terms was because the demand for labor dropped. Still, the market prices for water could only be tolerated by people who could get reasonable wholesale prices from merchants and distributors. They could only fetch good wholesale prices as long as the Canary Islands had a lock on Spanish and European markets and if there were no other local industries that were more profitable and powerful.

That situation did not last beyond the 1970's. The intensification and industrialization of agriculture, the deterioration of the aquifer, the reallocation of water rights, increasing market competition for banana and tomato from the Carribean and Africa, and heavy investments in the archipelago's tiny tourist industry altered the relative profitability of using water for agricultural and non-agricultural ends. The profit rates in agriculture declined sharply just as improvements in wages made it possible for more farmers to enter the wage labor force (CIES 1975; Martín Ruiz 1985) The resulting mass migration from the primary sector to the tertiary sector transformed the island's society and created some of the preconditions necessary for the large scale changes in water property regimes that I will describe in Chapters Seven and Eight.

Before I can examine some of the major changes in the water property regimes that have been occurring since the island's mode of production changed, I must describe and explain the role groundwater mining had in the transformation of agriculture, the rise of an urban society, and its effect on the relationship between the farmers, vendors, and the ayuntamientos.

The Transformation of Agriculture and Herding

The effect of groundwater mining on agriculture and herding varied according to location and crop. In general, lowlands farmers benefitted much more than farmers in the highlands. Although more than 20 ha of highland territory was brought under irrigation in Valleseco, most of its farmers lost all of their spring water by the mid-1960s. They had to buy water from the comunidades de aguas and vendors. The added cost of conveyance losses, capital investments for pipes, and exploitative market practices reduced the profitability of potato and corn production. Urban merchants soon found that it was cheaper to import from countries that relied on rainfall agriculture than to pay for domestic produce.

The effects of the change in water availability can be seen clearly by examining the costs and benefits of cultivating potatoes. The Canary Islanders had been exporting potatoes to England, Cuba and Venezuela at the turn of the century (Rodriguez Brito 1985). Now they import seeds and potato from Ireland and England. The Great Depression, World Wars I and II, the Spanish Civil War combined with local techno-environmental and structural problems to make Irish and English potatoes relatively cheaper than local supplies. By the late 1970's, seeds imported from England and Ireland represent 22.7% of a farmer's production costs. In addition, fertilizer amounted to 12.4%, insecticides 3.1%; various tasks 33%; taxes, 8%; rent, capital interest, and harvesting 6.61% of the total costs. Water represented 10% of their production costs (Rodriguez Brito 1985, 1995). As long as water costs could be controlled, potato farming could be profitable.

Most farmers lost their edge when their springs dried. A farmer needs an average of 3,500 m^3 to produce 15,000 kg of potatoes on one hectare. Water represents 20 to 50% of total production costs for farmers who buy it. If water costs 80 pts/m^3, then the farmer must spend 280,000 pts ($2,240) just on water. Thus, it costs 18 pts of water to grow each kilogram of potatoes. If water constitutes 50% of the production costs, then a farmer must sell for 36 pts/kg to break even. These days, the real cost of water is usually higher than 100 pts/m^3 (considering conveyance loss) so the average production cost is at least 23 pts/kg of potatoes (Rodriguez Brito 1986,1992, 1995).

The only way that farmers could withstand such high production costs is by selling in a market that consistently offers 60-80 pts/kg. But farmers can expect prices to hover around 40 psts unless summer demands and droughts drives prices up to 100 or 200 pts/kg. Prices that would make small-scale, full-time potato cultivation may not be seen again; the European Community, the Canary Islands legislature, and merchants now control local potato prices by storing imported potatoes from England in the Puerto de la Luz in Las Palmas and releasing them whenever summer prices begin their ascent. This year, importers injected over 700 tones of potatoes and caused local wholesale potato prices to drop after they reached 85 pts/kilo.

Even if farmers managed to get an average of 60 pts/kg by selling their winter and summer harvests, they still would not earn enough to make their labor comparatively more profitable than wage laborers. As of 1995, the average monthly salary in the Canary Islands was 166,614 pts. Meanwhile farmers trying to make a living off of one hectare by planting potato would receive a gross income of just 900,000 pts/yr or 75,000 pts/mo. And since they must invest 300,000 psts into the next crop, their real income falls to 600,000 pts/yr or 50,000 pts/mo. That is less than the 60,000 psts that wage farm workers receive by working on banana plantations and only 10,000 pts more than unemployment compensation. Even those people who love to farm can't do anything more than grow food for their own household food stuffs and sell whatever they can't eat.

Similar stories can be told about corn and milk. The Canary Islanders used to export corn. Now they import it. The change has angered farmers who complain that rather than produce corn to make their own gofio and sell the remainder on the international market, merchants now import corn from Argentina and the United States. Dairy farmers are just as outraged. The state run dairy industry purchases milk from farmers at relatively tight wholesale prices, waters the milk down, mixes it with milk imported from Holland or the British Isles, and adds preservatives. While the products are very popular because they last and are relatively cheap, the reduced profit margins have made it virtually impossible for young farmers to take over the family business.

The fortunes made by the coastal farmers rose and fell with groundwater mining. As long as the pozos and galerías were churning out water, farmers with as little as one fanegada (slightly more than .5 hectare) could live in relative comfort despite the manipulation of the water market, conveyance losses, and theft. Adults look back on the period between the 1950s and 1970s nostalgically. The entire area below 300 meters was covered by a sea of banana leaves. Although farmers complain that packing houses and vendors cheated them constantly, there was no war, famine, unemployment, drug addicts, truancy, violent crime, or public scandals. The marvels of the modern world were becoming available. People built comfortable houses and filled them with new appliances. Many traveled for the first time when not on military service.

Farmers took advantage of flood irrigation techniques to multi-crop subsistence and export crops. They dedicated as much land to corn as to banana in the Comarca de Arucas in 1955, banana and corn each occupied 41% or 892 Ha of the 2.144 Ha cultivated (Martín Ruiz and González Morales 1990: 37-42). They also grew boniato, batata, wild maize, cabbage, calabash, and beans. The number of parcels owned, rented, or share cropped rose between the 1950s and 1970s and fell afterwards (Ruíz and Morales 1990). In addition, the distribution of crops changed. By 1984 only 1,152 ha were in cultivation; farmers grew banana in 62% of the area; fruits (papaya, mango, lemon, orange, avocado) on another 6%, tubers on 11%, vegetables on 6%; corn on 13%; and sugarcane on the remaining 2%.

Land tenure remained highly concentrated. In 1958, 82% of the landholders in Arucas had less than 1 Ha. 14.6% held between 1 and 5 ha. Only 68 people or 3.4% of the landholders had more than 5 ha. Of these 34 had between 5 and 10 Ha (Perez Marrero 1991). The distribution of land was similar through out northern Gran Canaria (Martín Ruiz and González Morales 1990). In Arucas 77% of all of the farms were less than half a hectare and 11% were between half and one hectare by 1991. Another 11% of the farms ranged from 1 and 5 ha. Just 1.2 % had more than 5 ha.

Not only are the vast majority of farms through out the area small, they tend to be divided into smaller parcels. There were about 2.58 parcels of land in each farm in Arucas, 2.98 parcels in Firgas, and 3.30 in Valleseco (ISTAC 1993d). In Arucas, 48% of the farms only had one parcel. Another 21.8% were divided into two parcels. The rest had three or more parcels. An estimated 60% of these parcels were smaller than 0.1 ha, while 30% were between 0.1 to 0.5 ha. Only 10 % were larger than 0.5 ha.

Most of the major changes in land tenure and crop diversity hinged on the relative profitability of banana cultivation (Table 6-1). Production costs vary according to the characteristics of the farm,

Table 6-1: Banana Production in Arucas, Firgas, and Teror Between 1940 and 1995 (Ha.)

Municipality	1940	1970	1977	1984	1995
Arucas	715	829	864	530	350
Firgas		127	99	78	60
Teror		6	22	12	8

Sources: Rodríguez Brito (1985); Instituto Estadística de Canarias (1993b); unpublished documents from the Consejería de Agricultura y Alimentación, and estimates made by farmers.

cultivation practices, and climatological events. Labor and water have always been the biggest expenses. Labor represents about 40% of the total cost of production. Farmers build terraces as high as 10 meters that stretch long distances. They also built acequias, water tanks, storage facilities, roads, and wind breaks. Then they prepare, and sometimes import, soil. After they plant and fertilize banana trees, they have to irrigate every two weeks for several months before the fruit appears. Farms that rely on flood irrigation require 2 workers for every fanegada (6.444 m^2) because they have to break the soil before irrigating. Those using drip irrigation need 1 worker for every 2 fanegada. Workers now place plastic bags over ripening stalks to increase the temperature and humidity around the fruit itself. The height of the harvest season is between July and September. Many farmers try to time their harvest for the weeks preceding or following the main harvest period to take advantage of higher market prices. Once harvested, workers wrap the stalks in leaves, hay, canvas, or plastic covers and transport them to packing houses. Banana merchants employ men and women to clean, cut, classify, pack, and transport the bananas to the docks where they are loaded onto refrigerated ships bound for European markets. The packing houses are owned by cooperatives and wealthy families.

Bananas demand large quantities of water. Each Cavendish banana tree requires a growing area of about 1 m^2. A farmer can grow up to 1,800 to 2,000 banana trees per hectare (Hernández Gómez 1991). Twenty to 25% of the water applied by manta (flooding) is captured by the banana plant. Approximately 75% of the banana's weight is water. Bananas stalks can weigh anywhere between 25 to 75 kilos, but normally vary between 25 and 35 kilos and produce 75 to 80 tons of banana per hectare. Bananas grown in the open air and irrigated by flooding consume about 900 m^3 every two weeks during the summer or 14,000 m^3/ha of water during the year (or 2 kilos of banana per cubic meter of water). Farmers reduce water consumption by 20 to 30% by using plastic covered greenhouses and drip irrigation techniques. Despite the savings, water still represents 20 to 50% of the total production cost. The exact percentage varies according to whether or not the farmers have to purchase water on the market. The more water the farmers own and the less they purchase, the lower their production expenses.

Farmers tried different ways to beat the contracting and exploitative banana and water markets. They produced 2.0 to 3.4 kg of bananas per cubic meter of water. By 1971, water could represented as much as 70% of the total production costs to small scale farmers who bought it on the market (Rodríguez Brito 1986). Many switched from flood irrigation to spray and drip techniques Although consumption rates decreased by 40% and production rates decreased only by 17%, water was still relatively expensive. Coastal farmers' income who used drip irrigation saw their water bills amount to 30% of their wholesale returns. Farmers who used flood irrigation techniques in the higher altitudes saw their water bills consume 61% of revenues. As the international market constricted, their average income decreased; it fell between 16 and 20% between 1978 and 1980 alone.

Some farmers who could not acquire fresh water irrigated with saline water. Many destroyed their farms in the process. Others invested in water efficient technology. They often sought state subsidies to reimburse them for between 25 to 75% of their bank loans. Farmers complain bitterly that they had to amass seemingly trivial documents and motivate bureaucrats in several different, poorly coordinated agencies. Few of the farmers had the time. Wealthier farmers hired assessors or lawyers to do the work. The efforts and costs involved in securing the state's aid was too much for many small farmers. Even if they managed to get state aid, they sometimes did not receive it in time to make bank payments, and lost their farms. Many grew tired of the mounting difficulties and falling return rates. Rather than move bureaucratic mountains only to loose money to water vendors, bankers, fertilizing and pesticide companies, produce merchants, and the state itself, farmers began shifting to salt tolerant crops, leaving farming for wage jobs, or retiring. Landowners in Bañaderos, Arucas began mining their fields; they sell their sand to construction companies. The rapid collapse of agriculture along the coast makes areal photos look like a checker board because most of the smaller farmers have already abandoned their fields while the larger farmers struggle to continue.

The economy of scale protected those who owned and operated relatively large farms. Martin Ruiz (1990: 85) estimates farms larger than 50 ha represent just 1% of the total number of farms but they cover 67% of the territory. They represent 0.6% of the land in cultivation and cover 23% of it. Lastly, they account for 1.6% of the uncultivated farm, but 78.5% of the uncultivated land. Farmers in Arucas and Firgas say that these days they need to cultivate bananas on 4 fanegada (2.5 ha) to feed a family of four. Only 12% of the farms in Arucas can sustain such a family.

Most of those who continue to produce banana are facing a terribly uncertain future. The smallish sweet Cavendish bananas, which are the bananas of choice among Canary Islanders, are not in high demand in the international market. Canary Islanders chide American and European consumers for preferring larger, drier, and flavorless bananas that are not easily bruised during transport. But they know that they have to sell what the market demands and are now cultivating Williams, Johnson, Nanição, and Valery varieties (Hernández Gómez 1991).

Even if they successfully adopt these new varieties, the Canary Islanders will have to overcome some strong competition in both the market and political arenas. American and British fruit companies who rely on rained agriculture in Africa, Central and South America, and the Caribbean are placing tremendous pressure on the United States to renegotiate European Trade Quotas so they can capture a larger share of the European market. The outcome of the negotiations remains unsettled.

The health of the livestock industry was closely tied to agriculture and international markets too. Competition from the European dairy industry, the rise of state controlled dairy processing plants, and commercial restrictions on farmers made it virtually impossible for small farmers to make a substantial profits by raising cattle, sheep, goats or chickens. People throughout the Canary Islands lament the loss of their farmland and livestock. Older residents point with ease to areas where cattle pens used to stand. Even those who own large plantations will escort you to empty pens or troughs and reminisce. Those who still have goats and cattle are struggling to increase their European Community subsidies so they can afford to continue farming, butchering, and selling dairy products.

Water People, Not Crops

According to a study by the Instituto Valenciano de Investigaciones Económicas, the Canary Island economy grew at an average rate of 5 22% between 1955 and 1995, making it the second fastest growing and volatile economy in Spain after the Balearic Islands (Canarias7, Nov 6 1996). The BBV Foundation (Canarias 7, Oct. 31, 1996) reported that the average wage rate rose enough to narrow the gap by 7.63% to 12.86% off Europe's average during the same period.

The Canary Islands achieved such a phenomenal growth rate because the archipelago's government and the elite used state development funds and attracted European and Spanish venture capitalists to build immense tourist havens on Tenerife, Gran Canaria, and to a lesser extent, Lanzarote and Fuerteventura (CIES 1976, 1977). The tourist industry now hosts over one million visitors every year. Their business accounts for about 80% of the archipelago's gross domestic product. The center of tourism on Gran Canaria is located on its southern coast in Playa de Las Canteras, Maspalomas, Playa de Inglés, Puerto Rico and Mogán. Most recently, they have done everything they could to foment the construction of time-share apartments to attract Europe's vacationers and retirees. The massive investments strengthened the construction, manufacturing, and service industries.

The rapid growth and relative profitability of non-agrarian economic activities affected the demand and allocation of water resources. It became even more profitable to use or sell water for services and construction than for agriculture; the production and sale of water and energy continue to be the most profitable industries in the archipelago. The intensification of water production underwrote the growth of the entire economy. By 1977 water represented just 1.3% of the archipelago's wealth but it had become a critical input in all of its 31 economic sectors (Jiménez Suárez 1981) The agricultural sector soon found itself losing the competition over water resources with far more profitable enterprises. The service sector earned 80 times the amount farmers earned by consuming one cubic meter of water Industrialists earned 40 times what the farmers did. When examined from the point of view of returns on labor per cubic meter of water consumed, the services and industries earned 35 and 20 times more than the farmers. Yet agriculture consumed about 80% of all of the water produced on the island. Such an imbalance would not last long because resources tend to be allocated to those activities which will maximize the return on investment for its property holder.

Another indication of the massive change in the island's mode of production is the relative percentage of electricity consumed by water production. Although the total amount of electricity consumed in the water industry is rising steadily, the percentage of the island's electricity devoted to water production is declining. In 1974, water production consumed 82% of all island's electricity but only 26% in 1990 (Dirección General de Obras Hidráulicas 1974: 232; Custodio 1990:348). The decline of the percentage of the island's energy consumed by the water industry should not be taken as a direct measure of its importance because the other economic sectors would not be possible without a reliable source of water.

The Transformation of the Labor Force

I've argued that major changes in the external markets create opportunities for local and foreign agents to make productive investments. These opportunities and the techno-environmental conditions of the island influence the kind of investments they make. Whenever there are major shifts in the basic means of production, we will most likely find adjustments in the labor force, the island demography, and the norms regulating everybody's access to scarce resources. In this case, the reallocation of water supplies from agriculture to non-agricultural activities occurred because the upper class, the Spanish state, and international venture capitalists financed huge tourist colonies.

The mass migration in the labor market created a stunningly clear generation gap The occupational profile changed rapidly By 1975, more people worked in the secondary and tertiary sectors than in the primary sectors While many middle-aged and elderly farmers continued to work their fields, younger farmers and their children either entered the job market or sought university degrees. The Universities of Las Palmas and La Laguna in Tenerife have become major international research centers that train the next generation of engineers, marine biologists, professionals, social scientists, and bilingual workers.

Even a brief look at the occupational structures of Arucas, Firgas, and Valleseco will verify the archipelago's shift from the primary to the tertiary sectors. In 1860, 1,072 household heads in Arucas worked in the primary sector. Most were farmers and fisherman. Another 61 worked in the secondary sector while 274 worked in the tertiary sector. By 1975, although the number of laborers in the primary sector had grown to 2,609, the secondary sectors swelled to 3,105 and the tertiary ballooned to 5,508 workers (Martín Ruiz 1985; Instituto Estadística de Canarias 1993a; Ayuntamiento de Arucas 1993a,b, 1994a,b). By 1991, 10,072 people, or 36% of its population, was actively engaged in Arucas' labor market. Of these, 6,949 or 69% were employed. Thirty one percent were officially unemployed, although many of these people work in the informal economy. Only 299 people, just 4% of the active adults, were employed in the primary sector. Half of the workers were over 50 years old. Unlike their older compatriots, the few young workers can not count on lifetime job security because farms and packing houses are cutting their labor and benefits costs by hiring new employees through temporary contracts. Another 3,095 persons (44.5% of the active population) were employed in the industrial sector. Most were men who did construction work elsewhere in the island. Lastly, the service sector accounted for 5,156 or 51.2% of the labor market. Although 77.7% of these jobs were held by men, this is the only sector in which women have made their presence felt (Martín Ruiz 1985; Instituto Estadística de Canarias 1993a; Ayuntamiento de Arucas 1993a,b, 1994a,b).

Both Firgas and Valleseco underwent similar structural changes (Martín Ruiz 1985; Instituto Estadística de Canarias 1993a,b,c,d). The number of farmers, herders, and fishermen in Firgas increased from 215 in 1860 to 436 in 1975 but fell to 89 by 1991. Meanwhile, the size of the industrial labor force rose from 10 in 1860 to 1,851 in 1975, before dropping quickly to 566 in 1991. In contrast, the percentage of people in the services sector is growing; of the remaining 1,433 active adults, (778 or 51%) work in the services sector.

The shift from agriculture to wage labor in Valleseco is as clear as it can get (Martín Ruiz 1985; Suárez Grimón 1990; Instituto Estadística de Canarias 1993a). The number of farmers in Valleseco dropped from 704 in 1860 to 626 in 1975. There are only 156 today. Most are elderly In fact, local farmers can think of only 3 men under the age of 50 who farm full-time. The number of laborers in the industrial sector went from 70 in 1860 to 608 in 1975, and back down to 337 in 1991. Most work outside of the municipal district. The bulk of the work force in Valleseco (581 or 54%) is dedicated to the service sector and work elsewhere.

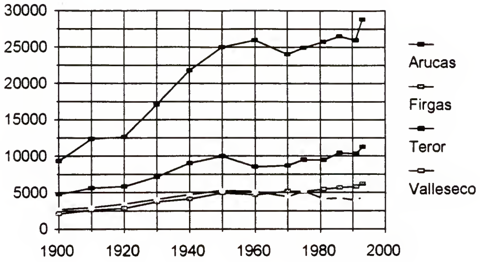
Changing Demographic Patterns

The demographic characteristics of the population responded to the demand for labor. The average population growth rates were higher between the fist half of the century than the second half. The population of all of the municipalities rose during the first half of the century while water was relatively plentiful and the need for agricultural labor was great. The population levels peaked in the highlands during the 1970's as young adults went to the coasts in search for employment (Table 6-2; Figure 6-1). The Comarca de Arucas grew at a rate of 2.6% between 1920 to 1930 and 2.1% the following decade. The growth rate slowed to 1.2 during the 1940's, and afterwards declined to -0.09 in the 1950's and -0.5 in the 1960's. It picked up slightly in the 1970's as farmers from the highlands began moving to the growing coastal urban areas in search for jobs (Martín Ruiz 1985: 86-88).

Table 6-2: Population in Municipal Districts Between 1990 and 1993

Year	Arucas	Firgas	Teror	Valleseco	Gran Canaria
1900	9,367	2,088	4,794	2,689	127,471
1910	12,374	2,614	5,616	2,936	162,601
1920	12,649	2,854	5,823	3,420	173,552
1930	17,087	3,713	7,144	4,077	216,853
1940	21,804	4,097	9,049	4,727	279,875
1950	25,010	4,934	9,992	5,256	331,725
1960	25,986	4,668	8,545	5,112	400,837
1970	24,030	5,176	8,720	4,423	519,606
1975	24,954	5,123	9,493	5,154	633,704
1986	26,519	5,655	10,449	4,254	745,812
1991	25,986	5,772	10,341	3,891	654,001
1993	28,834	6,152	11,276	4,458	665,426

Figure 6-1. Populations of Arucas, Firgas, Teror and Valleseco Between 1990 and 1993



Nuptial rates increased between 1910 and 1930, declined during the Civil War, and then increased again between 1940 and 1944. Natality rates are lower among the upper middle and upper classes than the lower classes (Martín Ruiz 1985: 336). Older Canary Islanders typically explain that they had more children because they didn't have to commute to work on the other side of the island every day, needed children to work on the farm, and quite frankly, didn't have electric lights, TV's, movies, bars, restaurants, discos, and drugs to dull their more amorous urges. They are also likely to agree with younger adults who simply say that it is just too expensive and difficult to raise many children today.

The mortality rates responded to periodic epidemics such as influenza in the first few decades of the 20th century. The mortality rates declined beginning in the 1950s as the state government introduced sanitary systems, as well as health, food, hygiene, and medical programs.

Public Investments in Water Services

I have already explained that the ayuntamientos were forced to make deals with the comunidades de aguas to guarantee public water supplies. Now I wish to explain how their initial dependence on the comunidades de aguas and the transformation of the island's mode of production caused the ayuntamientos to become the dominant consumers in the island's water markets by the mid-1980's.

The ayuntamientos struggled to secure water supplies as more families saw their springs dry throughout the mid-century. Nearly all of the residents on the island became completely dependent on the ayuntamientos for their domestic water supplies. Ayuntamientos regularly listed shortages of potable water and distribution systems as their most urgent problems in their annual reports and budgets. Every time another spring went dry, ayuntamientos made arrangements with private institutions to secure supplies.

But water supplies were not enough. Since the homes had largely been constructed with reference to nearby springs that had dried, the ayuntamientos had to construct a series of public fountains and spigots called *pilares* so that residents could fetch water The ayuntamientos tapped public springs and laid pipeline to connect water deposits holding water they acquired from comunidades de aguas with strategically located pilares. Later, the ayuntamientos extended the pipes to the households because the direct links between the municipal deposits and *biddones* (household water tanks) reduced the risk of water contamination and gave ayuntamientos a way to measure water consumption and bill each household.

Public and private expenditures on water works increased enormously from the 1930's onward. Judging from data from Valleseco, the private sector invested at least 15 times more than the public sector on water works. Valleseco estimated that between 1936 and 1964, both the public and private sectors invested 52,530,000 psts to construct at 231 tanks, 18 galerías, 38 pozos, and 39 50 km of pipeline (exp 57 (16)). They spent another 28,605,000 pts between 1964 to 1968 to either construct or modify 15 tanks, 22 galerías, 26 pozos, and 16 km of pipes (exp 43(16)). The ayuntamiento spent 3,319,000 pts in state and its own funds to modify public water sources and build deposits, pilares, and conveyance network. It spent another 1,775,000 pts between 1964 and 1968 (exp 43(16))

I have not found comparable statistics for either Firgas and Arucas for the same period, but suspect that the investment trends are similar. Firgas inaugurated its first distribution system on June 3, 1939 (Incoming Correspondence # 305 Valleseco, 1939). Although Firgas enjoyed access to Los Chorros, deepening water shortages forced it to consider expropriating water in 1956. Twelve years later, in 1968, Firgas calculated that it had laid 14 km of pipeline that connected 4 deposits with 23 pilares. In comparison, Arucas began providing water as a public service in 1937 and quickly expanded the scope of its operations. It purchased rights to the Heredamiento del Molino, opened a pozo in Valleseco, and build its own pipeline. The ayuntamiento estimated that it owned 10 pilares and

25,492 meters of pipeline in 1955. Arucas regularly purchased water from the members of the Heredamiento del Molino since the 1940's.

According to the Instituto Valenciano de Investigaciones Económicas, the public investments in roads and public water works in the Canary Islands quadrupled between 1961 and 1995. This is a reflection of the greater disposable capital that Spain acquired through international development banks as well as the taxes revenue coming from its expanding agricultural, industrial, construction, manufacturing, and service sectors. It also represents Spain's commitment to urbanization and the tourist industry because both presume functioning road, telecommunications, and water facilities.

The Ayuntamientos Enter The Market

The public and private investment patterns were complementary as long as ayuntamientos could use their rights to take a portion of the water produced by comunidades de aguas who had given them libradas in exchange for mining rights. The ayuntamientos' involvement in the market as either vendors or buyers grew steadily throughout the 20th century. They had always either sold surplus spring water, but they rarely had surpluses, the revenues were tiny.

The ayuntamientos entered the market as large consumers with a severe disadvantage. Cabrera Hidalgo (1970) has special insight to the matter because he worked as the Secretary of the Ayuntamiento for the municipalities of Arucas and Las Palmas for about 20 years. Furthermore, he is the president of a comunidad de aguas, and runs a family farm. He argues that the ayuntamientos' water management practices drove them into deficit spending during droughts. Ayuntamientos were forced to establish long term contracts with vendors who could change their prices almost at will in order to offset the loss of their springs and declining productivity of the wells to which they owned libradas. However, they could not adjust their own municipal water prices because they had to get the permission of the Civil Governor and the Regional Commission for Technical Services to revise their tariffs. That process was mired in bureaucratic detail work; it took Valleseco at least 3 years (1970-1973) to revise its tariffs because the ayuntamiento did not exactly adhere to the commission's guidelines. As such, the ayuntamientos could almost never sell citizens water at the rates that would cover their own expenses.

Another problem arose from the ayuntamientos' purchasing and measurement practices. Like the farmers, ayuntamientos purchased and measured water from the point of departure. Vendors had to calculate the amount of water they sold to the ayuntamientos because they themselves lacked adequate measuring devises. Furthermore, they suffered high conveyance loses and their residents broke their meters to avoid paying for water.

Municipal reports illustrate just how bad the situation was. Firgas saw water production at Los Chorros fall from 15,147 m^3 in 1967 to 12,545 m^3 by 1969, and so bought more water on the market. It purchased water for an average of 8 pts/m^3 but charged only 4.6 pts/m^3. Meanwhile, it lost about 15,000 m^3 or 16% of the water to infiltration and other unstated causes (Ayuntamiento de Firgas exp: 17(15) 1970). Arucas had already lost El Norado and Fuente del Hierro. Its pozo in Madrelagua became too expensive to operate by the mid-1970s. Technical errors made its effort to operate a desalinator in San Juan XXIII a complete failure. It had to buy the bulk of its water from vendors who bought it from comunidades de aguas in Tenoya, Teror, Firgas, Arucas, Valleseco, and Moya.

Valleseco's loses were horrendous despite the fact that it didn't purchase water. The amount it received from the Heredad de Risco Gordo fell from 1.5 liters/sec to 3/4 liters/sec by 1970. The ayuntamiento still had rights to 10 liters/sec or 18 m^3 from the comunidad de aguas, Los Pinos, Vereda del Palo, and Casas Viejas. But their pozos, Huerta de los Pinos, El Prado, and Casa Vieja no longer produced on a continual basis. The ayuntamiento's expenditures were 30 times than its revenues in 1967. The ratio declined over the next two years to 21:1 and then 17:1 as the ayuntamiento repaired its pipelines. It water loses were about 20% in 1971 (Ayuntamiento de Valleseco exp. 17(15) 1970).

In some cases the ayuntamientos tried to buy mineshafts, but. the results were almost always disheartening because they could neither afford high production costs nor defend themselves against law suits Cabrera (1970: 164-165). The distribution of mining concessions during the 1930s and 194's and the natural hydrogeological flow of water made it virtually impossible for them to find a well in an area that either was not already claimed. Whenever the managed to open wells, speculators with old concessions to nearby sites typically began excavating and demanded to be compensated for any water they might lose. If they bought existing wells with illegal works, they became liable for all of the legal problems. Even when they managed to open or buy a legal shaft, its usually became too costly too operate as the water table fell.

Valleseco's experience with its pozo, El Prado, is almost a perfect example of Cabrera Hidalgo's point. The ayuntamiento exchanged mining rights with the Comunidad Vereda del Palo for rights to a portion of water. It purchased all the rights to the pozo for approximately 11 million pesetas in 1984. Some residents immediately accused the ayuntamiento of operating an illegal mine The case departs from the norm because the conflict over the Water Laws of 1987 and 1990 interfered with legalization process. The pozo was an expensive loss.

Most ayuntamientos eventually had to rely almost completely on the market. Even those who could produce desalinated water, such as Las Palmas, purchased groundwater to take advantage of cheaper rates. The ayuntamientos had some advantages in the market place. They ordered comunidades to sell water, paid better prices than farmers, and could use relatively saline water. Speculators benefitted even when farmers did not. Valleseco, Firgas, Arucas, and Teror quickly became the largest consumers in their region. Firgas, which needed 90,000 m^3/yr to supply its residents, increased the amount it purchased from 39,978 m^3 in 1967 to 70,650 m^3 in 1969. By the early 1970's, it bought all of its water. Teror purchased all of its 380,165 m^3 water by 1972. Arucas bought 1,099,844 m^3 in

1978 Valleseco began buying water on a regular basis in 1970. Local vendors estimate that the ayuntamientos bought 40% of all of the water produced in the region by the late 1980's.

Even though they dominated the consumer market and enjoyed legal priorities, the ayuntamientos encountered familiar problems. One report done in Arucas in 1977 summarized the situation.

> This office believes that the basic reason for the municipal water deficits has its origins, not in the public surcharges, but in the uncontrolled and unreasonable price increases on the part of the water suppliers. We do not believe for one moment that the extraction costs reach the 43 to 50 pts/m^3 (168-195 in 1990 pts) that they charge irrigators and ayuntamientos, and consequently, we think that the tariff increase is only one implicit way to benefit the water owners who act shamelessly for their own profits by pressuring the politicians and municipal coffers. It would be more efficient, in our way of seeing things, to really control the costs of production and regulate market prices. [1]

In 1983, Valleseco asked a consultant to evaluate its proposed surcharge rate increases. The consultant found that the changes would be ineffective if the ayuntamiento did not improve its technology and water management practices. The first thing it had to do was measure the amount of water it received from vendors. According to its own records, the ayuntamiento was losing nearly 47% of the water it claimed that it received from its own sources and vendors. But its conveyance system could not have been that inefficient and still delivered water under pressure. The chief engineer and ayuntamiento suspected that the problem was that they were not accurately measuring the water that entered the municipal water deposits. Furthermore, they suspected that the vendors might not be reliably measuring the water they distributed. So the ayuntamiento experimented. It stopped buying water from a comunidad de aguas that used a cantonera to measured its water and began buying water from a comunidad de aguas that used volumetric gauges. Water loses were cut in half. The engineer suggested that the ayuntamiento replace all of its cantoneras with volumetric meters, build a permament and impermeable distribution system, watch for broken meters, and control price fixing.

The ayuntamiento in Arucas went further after it learned it could not account for half of the water it bought. Dilapidated water mains, poor accounting systems, a faulty desalinator, and broken meters accounted for about half of their loses. The chief engineer installed meters at the entrance and exits of all of the ayuntamiento's water deposits and informed vendors that it would pay for the amount of water that entered the deposits. The change placed the burden of conveyance loses on the vendors themselves. In addition, he began replacing the ayuntamiento's decaying cement pipes with PVC piping and installed a computerized system that could pinpoint broken water meters by identifying those whose meters whose readings did not change over the course of several billing periods. These measures reduced losses by 20%.

These measures came at a good time because virtually the entire island's population was dependent on the ayuntamientos for their water. By 1977, over 98% of Gran Canaria's residents had domestic supplies of water and 95% received their water from ayuntamientos (MOPU 1977). Urbanites were more likely to receive municipal water than rural dwellers. Families living in less developed areas like Valleseco and Teror received municipal water twice a week. Those living in coastal and urban areas like Las Palmas, Arucas, and Maspalomas receive water more frequently Half regularly experienced cuts in their water supplies. Eighty two percent relied on multiple water supplies. Sixty seven percent turned to alternative sources of water because the municipal water supplies were marginally potable. Another 12.7% complained about both the quantity and quality Only 2.4 % sought additional supplies because they could not get enough water. Seventy five percent said they did not drink the municipal water. Residents complain that it causes digestive disorders and literally destroys plumbing fixtures; they will use municipal water to clean or to cook, but will not drink it. Even though the ayuntamientos have made significant changes in their management practices, the high cost of water and tremendous conveyance losses have made the prices ayuntamientos charge the highest in Spain (Meneses Martin 1990).

The Bottled Water Industry

One of the consequences of the destruction of the springs was the creation of a vigorous bottled water industry that supplies citizens with potable water when the ayuntamientos can not. The average person on Gran Canaria drinks approximately 200 liters of bottled water every year. That is four times greater than the average for Spain and twice the consumption rate in France. Needless to say, the potential profits are enormous. The archipelago's relatively small industry generated 16 million dollars in gross receipts by 1989 (Empresa Canaria 1990). The profits have only grown since then (Dinámica 1992). Of the 15 brand names operating in the archipelago that year, 13 were based on Gran Canaria. The biggest operators are Aguas de Firgas, San Roque, Agaete, Teror, and Cumbre de Gáldar. One and five liter bottles of water sell for 50 and 100 psts in the grocery stores and bars in the north. The same bottle costs about 200 psts in the tourist zones.

The profits are attracting new competitors. Farmers are forming new companies like *Del Campo*. Some of the businesses are not legally constituted, but are unburdened by overhead, highly motivated, and offer better prices than the larger companies. The competition has become so intense that major market holders are now negotiating to avoid price wars.

Bottled water companies began operating on the northern side of Gran Canaria since just after the turn of the century when the European interest in the health benefits of mineral water drew investors' attention to the waters flowing in Las Madres. Although the mineral health spa proposed by investors during the 1920's were never constructed, the interest was enough to promote investments in bottling. There are now four bottling factories in Arucas, Firgas, Valleseco, and Teror. Aguas de la Cumbre, which operated in Valsendero during the 1970's and 1980's, was crippled by legal and business disputes. Aguas de San Roque (which controls about 25% of the market) recently purchased the dilapidated company's pozo, but not the factory itself. A popular rum manufacturer called Ron de Ahrucas has operated in Arucas for at over a century. It produces its own sugar, maintains its own pozos, and makes purchases on the market. While its presence is notable, it has not made a decisive impact on the water market. Aguas de Teror is owned by the municipality of Teror and has become the single largest source of employment and income for men in the municipality. The gaseous water is famous on Gran Canaria. The factory attracts people from as far away as Las Palmas who are looking for healthy, inexpensive water because it permits people to take water from one of its public pilares.

The largest bottler is Aguas de Firgas. It was founded in 1929 as a family enterprise and quickly united two business that operated in Las Madres, Firgas. Currently, it is owned by one extended family. Its naturally carbonated spring water became the water of choice among consumers. Since its springs were destroyed during the mining craze, the owners opened several pozos and started artificially carbonating its water to maintain a hint of its former flavor. Aguas de Firgas now owns and manages 14 pozos, most of which were purchased from speculators and struggling farmers in the lower half of Valleseco. It uses two pozos to produce its drinking water and two others for cleaning water. Although it doesn't frequently operate most of the pozos because their primary purpose is to protect local water supplies, it sells a relatively small amount of water from 10 pozos to maintain the equipment and its property rights. Conservation makes good business sense for Aguas de Firgas.

There are approximately 300 employees at Aguas de Firgas. Many are ex-farmers and pozeros. Sixty work in the bottling factory itself. The rest sell and deliver water. Most delivery men are independent contractors who purchase merchandise from the company, drive its trucks, and sell directly to businesses and houses within bounded sales territories. The company has such a tremendous presence on the island that it is difficult to imagine spending more than 5 minutes on any main thoroughfare in Las Palmas during the day without seeing at least one of its red trucks rumble by. The company now enjoys 50% of the market in the Canary Islands, and can be found in Spain and, to a lesser extent, in North Africa. It also bottles soft drinks like Pepsi and Fanta.

The future of Agua de Firgas is uncertain because it is a relatively small company in a relatively profitable market and responding to business incentives in a growing global economy (Canarias7 August 8, 1996) The company invested 1.200 million pesetas (9 6 million dollars) to modernize its bottling processes in 1992 and introduced a 3/4 liter bottle into the market in 1995 Since then, some of the most prominent bottling companies in the world have offered to purchase the company The most attractive deal has come from Perrier, the French multinational bottling conglomerate The current owners of Agua de Firgas are considering selling their distributing business, but suggest they will retain ownership of the company's pozos and the brand name

Water and Canary Island Identity

Jerónimo Saavedera, the Ex-President of the Canary Island's Autonomous Government, declared Agua de Firgas a *símbolo de Canariedad* (Symbol of Canary Island Identity) when news of Perrier's interest in the company was made public. His statement can be interpreted in several different ways. It could mean that he merely recognizes that the brand is widely known and closely associated with the Canary Islands. But that is unlikely because the archipelago's leading politicians are making more nationalist and regionalist appeals to identity politics as they negotiate with the Spanish Government, the European Community, Morocco, Canada, the United States, and other western powers over agricultural, fishing, and tourist markets. Saavedera's claim is more likely a way to glorify regional interests while recognizing the importance of maintaining some proprietary and commercial link between Aguas de Firgas and the Canary Islands; the company and brand name must not become a front for Perrier.

There is another interpretation that Saavedera probably did not hope for - but would be just as defensible; Aguas de Firgas is symbolic of this century's protracted conflict over property, wealth, markets, and political power. Most people in Valleseco and Firgas are genuinely proud to have the water that flows underneath their lands to be adored through out the archipelago. They enjoy its taste, say it mixes well with whiskey (although not as good as it used to), and it employs people. They respect the accomplishments of the hard-working individuals who have made the company succeed and never suggest that the company's owners be prevented from profiting from their labor and resources.

They also point out that the company's success has not been benign. Ex-farmers through out Valleseco and Firgas deeply resent having to buy water and to work for people and companies they blame for destroying their springs. Furthermore, people in Valleseco are disgusted that they cannot tax the wealth that flows from their subsoil.

The conceptual links between Aguas de Firgas and other aspects of the political economy were made painfully clear one night early during the field work when a man wearing a tattered Aguas de Firgas uniform spent three hours angrily lecturing me on why people in his area abandoned their farms, sold off their livestock and tiny plots of land, and sought low-paying wage work as construction workers, drivers, and servants. He vehemently blamed the *quatro gordos* (four fat people), or a metaphorical cadre of wealthy farmers, speculators, and government bureaucrats and politicians, for destroying modest farmers by promoting uncontrollable groundwater mining, constricting the options farmers had to market their produce independently of unscrupulous middlemen, and catering to developers who paid handsome kickbacks for land and construction rights. He was livid that public officials could let water owners store water in existing pozos and galerías and prevent them from mining deeper into the aquifer during a drought that left many of the relatively few remaining farmers frantically searching for enough to save their crops. He denounced the condition of the public drinking water and the inability of the island's population to farm its fertile lands and be self-sufficient. He hated having to buy expensive bottled water and seeing his children eat pre-processed junk foods when he grew up drinking clean spring water, *real* cow's milk, and eating food grown on his own farm. And, he was just as angry with university supported researchers who had previously done a survey that did not tell more than a small part of the entire story or lead to any changes. On the other hand, he was unwilling to conduct any formal interview because he suspected that the study I was conducting would only cause even more problems and make trouble for anyone who cooperated.

The struggle over water has been so strong that farmers, engineers, laborers, and water owners alike sometimes claim that each Canary Islander is 'una isla a su mismo' (an island unto himself). The insular environment, they explain, has caused genetic selection that favors the survival people who are terribly self-interested and incapable of cooperating. Given the opportunity, they would all seek their individual advantage. Therefore, they insist, they cannot work cooperatively in the heredades and comunidades de aguas. They apply the same argument to explain why, as they claim, public officials are just as corrupt as businessmen. No matter how hard they try, they wind up seeking their own advantage. The rest be damned.

The irony is that these very same people built a truly awe inspiring network of terraced fields, water and road works, electrical grids, houses, and businesses. They founded and operated hundreds, if not thousands of water management organizations, family and corporate businesses, political parties, interest groups and social clubs, and take pride in the strength of their extended families. They are struggling to cooperate, and as we will see in the upcoming chapters, there has been some progress, but neither natural selection nor Canary Island national identity are effective explanations.

Moreover, the symbolic importance of water brings Canary Islanders together. It has always been a feature of civil and religious ceremonies. The pre-Hispanic Canarios made water a central component in their most important religious activities, and the contemporary Christian and New Age rites are replete with their own references to water, some of which equate water with life. There are even some fiestas devoted to the celebration of water. For example, the Fiesta de Agua in Telde and the Fiesta de la Rama in Agaete both continue pre-Hispanic traditions by celebrating water's importance to life on the island. Thousands of people from through out the island converge on these towns to march, dance, eat, drink water and alcohol, and sing along canals and streets. During the celebrations they douse each other with water that they scoop from canals or sprayed by garden hoses. Civic leaders give speeches and write editorials about bygone eras and the changing *cultura de agua* (culture of water).

Water's symbolic importance is manifest in other ways. Each municipality has at least one ornate fountain near its ayuntamiento. The fountain in Valleseco is located in the church plaza and operates during the summer, assuming there is enough water. Arucas has several fountains located in different settlements. The largest is just outside the old Ayuntamiento near the municipal garden. As I mentioned before, there are also two fountains near the Heredad de Arucas y Firgas which serve as cantoneras.

Firgas has two fountains. One is dedicated by Aguas de Firgas. The ayuntamiento just finished constructing the second. The later takes the form of a series of step waterfalls approximately 25 meters in length. A bright spotlight shines on water spouting from a Blue Phonolitic stone plaque into a ceramic pot at the top of the fountain. The water spills out of the pot and descends down the steps to a small pool at the bottom before being pumped back to the top. Nearby, benches covered in bright ceramic tiles depict the shields of every municipality on the island. Valleseco's shield includes the images of an apple tree, cornucopia, church and pozo. Its motto is written on a banner that cups the bottom half of the shield. It reads, "Agua, Labor, y Tierra" (Water, Labor, and Land).

The value placed on water by citizens living in Firgas is clearly expressed by J. Solano's poem which is etched on the water fall's plaque where the water springs forth:

> Oh, Firgas Mountain!
> With affection your slopes pledge
> and from your interiors spring
> the most valuable good, water.

Summary

The 20th century has been tumultuous for the Canary Islanders. It should be clear that the demand for water created by the European market for bananas caused a series of technological and demographic changes that lead to conflicts over surface and groundwater. The pressure to intensify production caused historic transformations in the water property regimes despite near condemnation of specific groundwater mining projects. These same pressures created the private distribution network and fostered a market culture that seems to have integrated theft and extortion as fundamental norms.

The water management practices and property regimes essentially raised the costs of production in agriculture. The transaction costs could only be sustained as long as the external agricultural markets offered good wholesale prices. But the massive investments made by the Spanish state and private finance capitalists quickly made non-agricultural activities more profitable. The shift in profit rates caused fundamental changes in the labor force and the island's demographic profile. It also forced the ayuntamientos to construct water distribution networks and to enter the market as the largest consumers. These infrastructural and structural modifications have become some of the preconditions necessary for the most recent transformation of the property regimes.

Notes

1.

Esta oficina estima que la razón base de los déficits municipales en materia de agua, tiene su origen no en las tarifas de facturación al público, sino en el incontrolado y disparatado aumento de los precios por parte de los suministradores de agua. No creemos ni por un momento que los costos de extracción alcancen los 43 a 50 pts/m^3 que se facturan a regantes y Ayuntamientos, y por consiguiente, pensamos que la subida de tarifas es solo un medio de, implicitamente, favorecer que los propietarios de las aguas actúen, presionando las políticas y arcas municipales, descardamente en lucro propio.

Más eficiente, a nuestro modo de ver, sería un control real de los costos de explotación y una regulación de precios de venta en los mercados.

CHAPTER 7
WATER MANAGEMENT REFORMS DURING THE TRANSFORMATION OF THE SPANISH STATE

Anthropologists are increasingly concerned with the role of human agency and political action. They want to know how a person's situation affects his or her behavior. The issue is important, they argue, because it is human behavior that shapes our environment and our future. This argument draws our attention to individuals and political groups. Unfortunately, it also draws our attention away from the factors creating the situation in which people act as well as their causal role in determining what behaviors people are most likely to adopt and reject.

It should be apparent from my previous descriptions of conflicts over water resources and water law that the theoretical model guiding my investigation into the evolution of property rights grants individuals latitude to change their own situation. But it also claims that factors such as the dynamic international market and techno-environmental conditions are often beyond the an individual's total physical and political control and may direct him or her to adopt some behaviors and beliefs while rejecting, and often vilifying, others. As such, it is possible to identify fairly clear theoretical relationships between the factors that create the situations that people find themselves in as well as their responses.

In this case, the causal power of the factors shaping the economic and political interests of the actors in the Canary Islands must be clearly established in order to understand the political contests over water policy and law. We have already seen that the rise of the tourist industry in the 1960's and 1970's created an additional strain on water resources and caused a mass movement from agriculture to urban services. The shift also made virtually everybody dependent on the ayuntamientos for their water supplies. The only way the government could support the thriving tourist industry was to help provide better services including electricity, transportation, telecommunications, water, health care, commercial centers, law offices, social security etc... for the tourists, businessmen, and laborers. According to my model, these changes could only come at the expense of existing property relationships.

This chapter examines the intense political and legal debates over water property rights in the context of the Canary Island's adoption of desalination and water treatment technology as well as Spain's transition to a decentralized Republican Monarchy and its incorporation into the European Community. First, I discuss the long term adoption of desalination and water treatment technology. Then I turn to a brief explanation of why Spain shifted from Fascism to its current political and administrative system. Afterwards, I examine why Canary Island nationalism has been a useful devise for extracting financial and political support from both Spain and the European Community. These factors help explain how and why the battle over water property and administrative law quickly became a debate over political ideology.

Desalination and Waste Water Treatment Technology

The combined hydraulic demands of agriculture, construction, manufacturing, tourism, urban services, and domestic placed so much pressure on the island's aquifer that the quantity and quality of water deteriorated rapidly. They only way to avoid economic and ecological disaster was to increase the supply of potable and irrigable water. Fortunately, the coastal location of most of the island's consumers and developments in desalination and water reclamation technology are making it increasingly possible to increase the water supply for both agricultural and non-agricultural uses (Bergasa Perdomo and González Viétez 1995 [1968]; González Viétez 1985a,b; Cabrera Hidalgo 1970; Jiménez Suárez 1990a,b; Calero Pérez et. al. 1990; Dinámica 1992a d; Farinas Inglesias 1990;

Falkland 1991; Custodio 1990; 1991; Consejo de Obras Públicas 1983, Consejo Insular de Aguas de Gran Canaria 1994; Consejo de Industria y Comercio 1993).

Water desalination is the process of reducing dissolved salts such as magnesium, calcium, potassium etc... in water. Vaporization, reverse osmosis, electrodyalisis, and multi-stage flash are the most common techniques. Vaporization is nothing more than separating water from other compounds by generating heat in a pressurized tank, directing the distillate steam through conduits to water tanks, and rejecting brackish water. The condensate cools returns to a liquid state that can be transported through pipes and consumed.

Reverse osmosis distills brackish water by pumped it at high pressures through long, thin plastic tubes that contain long strings of densely packed fibers. The fibers attract negatively charged ions towards the outer edges of the tube. By the time water has traveled through the length of the tubes, much of its saline content has migrated towards the outer rim of the tubes. The two relatively different kinds of water flow into different tubes; one collects the desalinated water and the other dumps the brine.

Electrodyalisis requires water be pumped through stacks of electrically charged fibrous palates which separate the negatively charged ions from the flowing water. The electrical current that flows through the stacks is reversed every several minutes so that salts do not build up disproportionally in any of the palates.

In the multi-stage flash technique, heated water is forced into a series of chambers where vacuums reduce the atmospheric pressure and cause some of water to vaporize. The condensate is collected and channeled to a holding tank while the remaining brine is fed through the remaining chambers. The brine left after the process is dumped into the sea or ponds.

The energy and conversion efficiency of these capital, labor, and energy intensive techniques differs. Vaporization and multiple stage flash technologies produce purer water than either electrodyalisis and reverse osmosis, but they are also more energy intensive, and thus, more expensive.

Canary Islanders are building desalinators for seawater and saline groundwater through out the archipelago (Abbad et. al. 1990). There are already at least 15 plants that desalinate seawater on Gran Canaria alone (Table 7-1). Most of these were commissioned by the state and constructed by private contractors. Administrative responsibility for the plants were transferred to municipalities. The largest ayuntamientos formed or re-established public-private enterprises to manage the facilities. Typically, the concession holders contract with private companies such as EMALSA, Pridesa, Tedagua, Ionics, and others to operate the facilities (EMALSA1992, 1995). The contracts usually set targets for the production rate, water quality, and cost that the company must meet along with a fixed profit rate and incentives.

There are also a growing number of desalinators treating saline groundwater. Most of these use either reverse osmosis or electrodyalisis to desalinate the water and produce at rates far more modest than the sea water desalination plants. For example, of the 19 plants that Tedagua operates or maintains on Gran Canaria, the smallest produces 80 m^3 a day while the largest produces 2,400 m^3 a day. Together they produce 13,750 m^3 a day for an average of 723 m^3 (Tedagua, 1995). The oldest instillation was opened in 1983 and the number of new clients is growing exponentially. Their clients are a mix of individuals, families, agricultural cooperatives, and construction companies. Almost all of these plants are devoted to irrigation.

Waste Water Treatment

The island's municipalities began toying with the idea of building and operating water treatment facilities during the 1950s. However, since most of the municipalities did not have very large, dense populations, human waste was better disposed of in *pozos negros* and used as compost fertilizer. The archipelago received national funding to implement a coordinated project to construct

Table 7-1: Estimated Production Rates for Sea Water Desalination Plants on Gran Canaria

Location	Date	Desalination System	Production/m^3/day
Guia		Reverse Osmosis	
Galdar	1989	Reverse Osmosis	3500
Arucas	1995	Reverse Osmosis	5000
Puerto de la Luz		Vapor Compression	920
Jinimar/Las Palmas	1970	Multiple Stage Flash	13700
Jinimar/Las Palmas	1976	Multiple Stage Flash	12300
Jinimar/Las Palmas	1989	Reverse Osmosis	28000
Jinimar/Las Palmas		Vapor Compression	880
Gando		Reverse Osmosis	443
Aguimes		Reverse Osmosis	8000
Las Burras		Reverse Osmosis	5500
Salinas del Matorral		Reverse Osmosis	2800
Barranco Balito		Reverse Osmosis	178
Puerto Rico		Vapor Compression	1506
Playa de La Aldea		Vapor Compression	0

Sources: Plan Hidrológico (1995); Molina Abbad and Ibrahim Perera (1990) water treatment facilities throughout the archipelago launched in 1974 as part of a larger hydrological plan to modernize urban distribution and sewage systems (Rubio 1990; García Rodríguez et. al 1990; Suaáez Sánchez 1993) The Ministry of Public Works built 22 water treatment facilities between 1971 and 1990. Most were finished between 1986 and 1990 (Table 7-2). Nine of the *depuradoras* (treatment facilities) were constructed between Barranco Seco in Las Palmas, and Galdar in the north. Several others were constructed along the rest of the island's coast. The *depuradoras* were supposed to serve about 87% of the island's population and produce nearly 90,000 m^3/day. Most of the depuradoras treat the water in two stages. The solid materials are lifted out of the water then the organic materials are eliminated by stirring the sewage rapidly so that aerobic bacteria can thrive in an oxygen rich environment and eat the organic compounds. A couple use anaerobic processes. Once the waste water is relatively free of the organic matter, chlorine is added to kill the remaining bacteria.

The state retained ownership over the water and the facilities themselves, but passed the responsibility of operating them to the municipalities (Reyes 1990; Mateo Faura 1990). Unfortunately, the municipalities neither had the money nor the trained workers to operate them so all of the *depuradoras* operated far below their capacity if at all. Another complication was that the saline content of the water entering the facilities was too high for agriculture because the treatment process does not eliminate non-organic compounds. The concentration of salts in the effluent from the treatment facilities were even higher so the municipalities could not cover their costs by selling the water at prices that would enable them to improve water quality and operate the facilities profitably.

Still, many farmers with fewer than 5 hectares located near the treatment facilities acquired the untreated or partially treated sewage either for free or for minimal fees and irrigated their crops. Farmers mixed the sewage or partially treated waste water with fresh or less saline water to dilute the salts and killed off bacteria by letting it stand in tanks several days before irrigating. Even those who took soil and crop samples to the University of Las Palmas' agricultural research station and

Table 7 -2: Waste Water Treatment Facilities

Location	Date Constructed	Population Served	Maximum Daily Production	Current Production per day
Agaete	1989	5,000	500	400
Galdar- Sardina				110
Guia-Galdar	1990	30,000	3,000	2,000
Moya	1988	5,000	500	110
Firgas	1986	5,000	750	365
Bañaderos	1989	5,000	500	345
Arucas	1989	20,000	2,000	1,400
Teror	1994	10,000	1,000	450
Tenoya		6,000	720	330
Artenara		600	120	0
Tamaraceite	1988	12,000	1,400	1,400
Barranco Seco I	1971 and 1993	400,000	33,000	4,230
Tafira		6,000	720	240
San Mateo	1986	5,000	750	0
Tejeda	1986	1,500	225	0
Telde	1978	100,000	10,000	5,700
Gando	1989	5,000	500	225
Aguimes	1990	60,000	6,000	6,000
El Tablero	1987	3,000	300	300
San Bartolomé	1994	3,000		
Mogán	1994	4,000	800	0
San Nicolas	1986	10,000	1,500	600

Source: Plan Hidrológico (1995); Rodríguez García and Gutiérrez Monteiro (1990) vocational school located in Las Hoyas below Montaña Cardones for inexpensive analysis often lost their crops because they, under advise by salesmen working for chemical fertilizing or pesticide companies, added chemical products without keeping a constant watch on the chemical composition of the water too.

Farmers in Arucas and Firgas typically say they have seen enough neighbors fall into these common traps that they simply do not trust public or private agricultural engineers and will not use *agua mala* if they can get *agua buena*, even if the later is substantially more expensive As of now, farmers hope to use treated waste water, if and only if, it is of an acceptable chemical quality and available for prices that are competitive with other sources of water. As one farmer asked me, why destroy your farm for the same price you can make it profitable?

More Expensive Than Groundwater?

A prominent belief among Canary Islanders is that they are adopting desalination and reclamation technology because the cost of operating pozos capable of producing good quality water has skyrocketed. However, there are others who insist that there is plenty of fresh water left in the aquifer; the owners of the mineshafts are hoarding the water in an attempt to drive prices up As I explained in the last chapter, it is very possible that the real average cost of producing water in pozos and galerías has not risen substantially since 1974 - perhaps not since the mid-1950's. Therefore, it may not be true that the rising cost of groundwater production is driving the shift to the alternative technologies. However, technological innovations *are* reducing the average real cost of desalination and water treatment. It cost 47 pts/m^3 (315 pts/m^3) to desalinate seawater in Las Palmas in 1974. Innovations increasing the energetic efficiency of windmills and energy feedback systems have reduced the costs to between 125 and 175 psts/m^3 (97 to 136 psts/m^3). Thus, it costs 80 to 120 pst/m^3 (62 to 93 pst/m^3) to desalinate brackish water from coastal pozos using reverse osmosis technology

The cost of treating waste water is also declining in real terms. Partial water treatment cost 10-13 pts/m^3 (67-87 pts/m^3) in 1974 Treating waste water in two phases (eliminating solids and organic bacteria) now costs about 80 pts/m^3 (60 pts/m^3). Eliminating minerals such as magnesium, sodium, and potassium would boost the cost an additional 55 psts/m^3 to a total of 155 pts/m^3 (120 pts/m$^{3)}$

If one were to consider only the production costs of water, galerias and pozos would still be the most cost effective technologies. But the combined consequences of: 1) the deteriorating water quality in the most productive mineshafts; 2) contracting agricultural wholesale market prices; 3) growing demands in the public and service sectors; 4) conveyance loses; 5) market profits and theft; and 6) the possibility of gaining European and Spanish, and Canary Island state subsidies are making investments in desalination and water reclamation facilities increasingly cost effective.

These days, one azada of water from Valleseco can cost anywhere from 108 to 136 psts/m^3, assuming that no water is lost in conveyance. The wages and profits garnered by the water owner, vendor, and possible acequiero can now represent more than 50% of the total price of water. The real cost of water that consumers receive is between 10 to 40% higher than the purchase price because that is how much they lose in transport. Put simply, transportation and transaction costs can easily triple the price of surface and groundwater. At those prices, desalination and perhaps water reclamation become possible if the consumers can withstand the additional costs of more expensive technologies and keep profit rates to a minimum.

The trend towards desalination in the tourist and urban markets is growing by leaps and bounds because both offer relatively inelastic markets for water. Tourists and urban residents are willing to pay relatively higher prices for a given amount of water without reducing their consumption. In fact, since groundwater and desalinated water amount to just 1 and 2% of the entire bill at luxury hotels, tourists pay for their water without a second's thought. Hotel managers, eager to increase their profit rates, switch back and forth between groundwater and desalinated water whenever either become cheaper.

To a lesser extent, municipal demand for water is also inelastic. As I have already explained, municipalities are willing to pay as much as 20% more for water than the farmer whose plot runs along the municipal distribution system. The average household consumers enjoys the benefits of chlorinated water piped directly into the house. They want potable water and will pay slightly more for it. Even if it is not potable, they will still use it to cook and clean. Over the past 7 years, every coastal municipality has opened at least one desalinator to reduce their near complete dependence on private groundwater resource. As long as tourism remains viable, desalination may be an effective way to complement groundwater and surface water production and to hold profit taking on the water market to a tolerable level.

The agricultural sector faces the most difficult circumstances because it cannot withstand high water prices. The competition over agricultural markets in Europe is intensifying. Since their competitors in the Americas and North Africa face lower water and labor costs, the Canary Islanders must rely on European subsidies and protectionist policies. They must also find ways to reduce their own labor and water costs. The shift towards drip and spray irrigation techniques has reduced the demand for labor by at least 75% and has cut water consumption by 33%. The large plantations and wholesale warehouses are now cutting their labor costs even more by shifting from full-time to part-time labor contracts that will not cover employee benefits such as social security. That change will increase the profit rate for agricultural producers by a tiny amount. They could make far bigger strides by restructuring their water management institutions while minimizing conveyance losses, profit taking, and theft.

Battle of the Caciques

All of these market and techno-environmental shifts are creating new conflicts between producers and consumers. The individuals and organizations producing water for sale have vested interests in strong private property rights and weak public administrative control. They remain among the most powerful people in the archipelago. But, just as happened throughout the history of the island, the titles to water and managerial powers are shifting to those individuals and associations that can provide the necessary capital and expertise to make the technological investments that support the most lucrative economic activities. In this instance, the tourist agencies, agricultural enterprises, and public organizations are utilizing European and Spanish public funds to subsidize investments in desalination and water reclamation technology. They are realigning their own property relationships and are hiring multinational corporations to construct, maintain, and/or manage their water facilities.

Several people who have worked as public water management issues over the past 50 years characterize the ongoing transition as nothing more than a political battle between the old and new *caciques* for control over the island's resources. The old caciques are the old agrarian nobility, speculators, and vendors who reigned during the age of surface and groundwater. The new caciques are a diffuse group of the old nobility, vendors, hydrologists, civil organizations, engineers, multi-national and local water management companies that have public and private owners, tourist barons, construction companies, bankers, lawyers, and politicians.

The battle between these caciques is said to have extended into the political realm as a contest between left and right wing political parties that came about as a consequence of Franco's death Indeed, it is reasonable to argue that the political processes involved in the evolution of the new property regimes were facilitated by, if not temporarily mired in, the collapse of Franco's highly centralized bureaucracy. The subsequent legalization of leftist parties and the creation of a relatively decentralized republican monarchy Spanish government with autonomous regional governments enabled disaffected groups to press for their interests through legal means.

As the transition dominated the headlines during the 1970's and early 1980's, an obscure committee in the Canary Islands used two previous comprehensive studies to evaluate and propose technical and legislative solutions for the archipelago's water problems. Their suggestions touched off an intense public debate that raged through out the 1980's and early 1990's about the property status of water, related technologies, and the administrative powers that private and public interests would wield. The debate quickly assumed the aura of a crusade between political activists pushing for their own vision of monarchism, fascism, socialism, capitalist democracy, and communism.

I hope to show in the next two chapters that the solutions that many pressed for and the solutions that are being implemented are not the result of political ideology. They are the consequences of current market forces and techno-environmental conditions that are altering the capacity of competing groups to make technological investments and to reduce the institutional and transaction costs that operated under the private property regime. The next step in making this argument is to demonstrate that the political processes in the Canary Islands following Spain's transition from a Fascist Dictatorship to a Decentralized Republican Monarchy as well as its incorporation into the European Community can be explained as a response to modernization.

Spain's Transition to a Decentralized Republican Monarchy

Spain's industrialization at the turn of the century forced wage laborers, peasants, landowners, the church, the military, and the monarchy to clash over political representation and public policies (Tortell 1987; Sánchez-Albornoz 1987). Franco's rise to power during the Civil War protected the upper class, the church, and monarchy (to a certain extent) against increasingly rebellious labor movements and peasants. He skillfully created and managed a highly centralized political and administrative edifice that stretched outwards from Madrid. Civil officials in the fifty provinces were essentially conduits of information and taxes towards Franco and his civil government's Ministers. They, in turn, established policies and distributed funds for infrastructural and social investments (Donaghy and Netwon 1987).

The end of World War II signaled an end to 10 years of civil war and economic autarky. Spain sought relief. The United States initially blocked aid to Spain in retaliation for Franco's close ties to Hitler and Mussolini but made amends in the 1950's because they agreed to confront the same communist enemy. Franco secured Spain's membership into the United Nations, International Labor Organization, International Monetary Fund, International Bank of Reconstruction and Development, and the Organization for Economic Co-operation and Development. He began to nurture ties with the European Economic Community (Donaghy and Netwon 1987).

Franco used the international economic aid and autarkic social programs to modernize Spain. As we saw in Chapters Four through Six, he vigorously promoted policies to intensify agriculture and supported the construction and service industries. His government built state owned and managed enterprises in the energy, mining, transportation, and communications industries in order to provide the materials and services that businessmen needed to operate. The plan worked. Spain's economic growth during the 1960's rivaled Japan's as it became one of the top 10 industrialized countries in the world (Donaghy and Newton 1987; Tamames 1993). The relative prosperity, peace, calm, and absence of signs of urban decay such as unemployment, slums, crime, and delinquency have earned Franco a special, if ambivalent, respect among Spaniards today.

Many look back on the epoch longingly and would gladly trade today's decentralized coalition government for someone who could match Franco's iron hand and strict policies. Their hopes cannot be realized because it was Franco's effort to modernize Spain that destroyed his political edifice. The initial strides in computerization, rapid transport, communication, and multi-national corporate production and financing during the 1960's and 1970's required leading citizens, venture capitalists, and middle-class professionals to form stronger links to business partners without the blessings of the central state. Meanwhile, the central government's tight grip over the strategic energy, transportation, and communications industries where the real profits were to be made began to act as an impediment to modernization rather than its prime mover because it prevented the private sector from entering the most lucrative industries. If that were not enough to make loyal subjects question the wisdom of Spain's centralized administrative edifice, its budgetary policies made it clear that some regions and economic sectors benefitted at the expense of others.

The growing class divisions were matched by reinvigorated regionalist and nationalist schisms (Hayek 1992). European neo-Marxist groups worked to mobilize underground dissidents while old nationalist movements in the Basque Country, Catalonia, Galicia, and Valencia regained their vitality. The Canary archipelago developed its own nationalist movement in reaction to the destruction of small-scale agriculture, tourism, urbanization, and the immigration of public administrators and professionals from the mainland (Hayek 1992). The increasingly regionalist and nationalist positions of the elite and middle-class tempered the Canary Island's militant leftist independence movements.

Franco's failing health during the early 1970's provided the opportunity to enact political reforms through out Spain. He could not find any political successor capable of maintaining a fascist state. Even his own hand-picked successor, Prince Juan Carlos de Borbón, secretly planned to create a Republican Monarchy. Two days after Franco's death in 1975, Juan Carlos I became King of Spain and began using his dictatorial powers to open the political process. Within a short time, the government called for general elections. The Union of the Democratic Center (UCD) won the first election. It beat the Spanish Worker's Socialist Party (PSOE), the Communist Party of Spain (PCE), and the Popular Alliance (AP) which was composed of seven right wing parties that pledged their allegiance to Franco (Donaghy and Newton 1987).

Despite their enormous political and ideological differences, the parties negotiated a new constitution in 1978. Borrowing from European and American constitutions, the Spanish constitution codified basic civil, political, and socioeconomic rights. The constitution acknowledged the role of public enterprises while protecting individual rights, liberties, and property. It created a parliamentary democracy that separated legislative, judicial and executive powers while retaining the monarchy. It decentralized state authority and bureaucracy by establishing 17 autonomous regions (Donaghy and Newton 1987).

Water, Trade, Nationalism, and European Unity

The reformation of the Spanish state was accompanied by its inclusion into the European Community. In many respects, Canary Islanders are becoming more interested in their nascent economic and political ties to Europe than they are to their connections with Madrid. Europe supplies tourists and technology. The European Community provides the Canary Islands with strategic political support and development funds.

If examined from the point of view of the European Community, supporting the Canary Islands makes financial and political sense. The looming discrepancies in the economic powers of the European member states and the need to establish a common currency to make trade relations operate smoothly has forced the European Community to create aid and development programs specifically designed to strengthen Europe's weakest economies and boost the value of their currencies. The European Community's archipelagos and remote territories receive special assistance because they cannot avoid economic collapse without it (European Community 1988). The European Community provides trade protection to companies within its territories against foreign competitors. In addition, some of the European Communities development programs, like POSEICAN, REGIS I and II, LEADER I and II, and Structural Adjustment Funds have become extremely important to the Canary Islands. The programs provide critical funding for infrastructural improvements like highways roads, housing, medical facilities, energy, water facilities, and education. All of these programs are explicitly constructed to help the Canary Islands survive in the international market.

The nationalist rhetoric that the Canary Islanders politicians have adopted has to be understood in the context the Canary Island's historical and current relationship to Spain and Europe. The archipelago's colonial history, immigration, and international commerce foster some ambivalent feelings about mainland Spain. Many people claim to be Canary Islanders who, whatever their background, share more with American nation states like Cuba and Venezuela than they do with the mainland Spanish (Hayek 1992). On the other hand, many of the Canary Islanders are recent immigrants who have maintained social relationships with relatives in mainland Spain and other European countries. The Spanish Congress just bowed to nationalist pressures by declaring that Canary Islanders now be considered a nationality (Canarias7 Oct 31, 1996).

Canary Island nationalism has strengthened its negotiating position with Spain's national government. This past spring, the Canary Island nationalist coalition between the Basque and Catalan nationalists was enough to install José María Aznar (PP) as President and to eject Felipe González (PSE-PSOE) who had held the office for 12 years. National politicians are painfully aware that the Coalición Canaria (CC) could topple the Spanish coalition by withdrawing its support. The national government is trying to satisfy the archipelago's demands for constitutional reforms and heavy subsidies to complete expensive road, housing, and hydrological projects (Canarias7, Oct. 25 and Nov 1 1996).

On the other hand, the nationalists temper their stances so the Spanish Autonomous Regions can present a fairly united coalition to the European Community. Like the Canary Islands, most of Spain's autonomous regions are suffering from the inter-related problems: water scarcity; rapid desertification; international competition over agricultural, industrial, fishing, and tourist markets, decaying infrastructure; urbanization; and a growing dependence on European tourism and subsidies.

Thus, the economic and political interests that are creating the European supra-national federation and realigning the Spanish state are making it possible for the Canary Islands to rely on both the European Community and Spain to make reforms in the water sector.

The Debate Over Water Management Reform

By the early 1970's, most Canary Islanders were certain that they had to take strong measures to reform the water sector. Its rapid decay was cutting into economic productivity and causing a variety of social and health problems they could not afford. The reformation of the Spanish state laid down some of the political and legal principals they could rely on to solve their problems. Public and private investments and control over water touched off a debate that quickly embroiled individuals representing the archipelago's competing interest and political groups.

Juan Quesada Lopes (1981), a senator from Gran Canaria, outlined some of the constitutional principles giving the national and autonomous governments the duty and power to intervene in water issues. He added that any national and regional water legislation must address the archipelago's unique hydrogeological conditions and historical development in order to succeed.

Antonio González Viétez and Wladimiro Rodríguez Brito (1981a,b), both members of the Communist Party of the Canary Islands, argued that water property and administrative relationships had to change. The private sector could not even maintain current levels of water produce or forestall its deteriorating quality because they lacked the capital and technology to make improvements although owners could still profit enormously by transferring water rights in a speculative market. The state had to intervene, but could not do so until it acquired control over property regimes to water. They recommended that water be declared a public good and insular administrations be created to organize public and private activities.

A commission (Comisión Mixta Para la Planificación Hidrológica en las Islas Canarias 1982) convened and based its own work on the comprehensive SPA-15 and MAC-21 studies about the archipelago's hydraulic (Dirección General de Obras Hidráulicas 1974; MAC-21 1981). The commission concluded that Fuerteventura and Lanzarote's residents needed desalinators and water treatment facilities to attract tourism. Gran Canaria was in desperate shape because it already had tourists. Its water supplies were dwindling rapidly and growing urban social problems like unemployment, drug addition, and petty theft were beginning to harm the tourist industry. Tenerife shared Gran Canaria's problems, but to a lesser extent. The rest of the islands, La Gomera, La Palma and El Hierro enjoyed better hydrological conditions than the others, but they could never support a large tourist industry. Coming up with a single legislative solution to water management problems would be difficult.

The Mac-21 study also showed that the public itself was divided about the causes of their water problems. Most agreed that water scarcity, mismanagement, and the lack of desalinators contributed to their woes. Forty-seven percent thought that property rights contributed to the problems but 14% disagreed. Similarly, 38% blamed the distribution system while 17% did not consider it to be a problem.

The citizens could not agree about what remedies to take either. Twenty two percent wanted the government to create parallel public distribution systems. Twenty five percent wanted water de-privatized. Another 19% felt it should not be made public.

The MAC-21 researchers noticed that the respondents were confused about the very terms of the debate. They did not understand the word *gestión* (management). When primed, 38% said that the management system was faulty while 11% disagreed. Half of the respondents couldn't respond to the question at all. The authors concluded that residents were dissatisfied with the status quo, but did not understand the fundamental issues.

The commission concluded that the existing codified property and administrative relationships were terribly confused and completely inadequate for the situations they faced. The state would have to take a greater financial and regulatory role in water management, but insisted that private property would be protected. It suggested that insular water councils be formed to oversee water issues The councils would write and implement comprehensive water management plans Part of these plans include steps to regulate existing water works, promote public investments in desalination and water recycling, and limit groundwater mining to a sustainable level.

The response was immediate. Water owners were outraged by what they saw as vague, inconsistent recommendations and an insidious attempt to socialize or nationalize water. The Asocación de Agricultores y Ganaderos de Santa Cruz de Tenerife (ASAGA) accused socialists of using water reform legislation to extend their grasp to degrees that hadn't been achieved by their counterparts in other Western European countries. In addition they complained that the officials proposing the changes ignored the industry's complex social dynamics, minimized the contributions made by private organizations, and failed to learn from previous state failures (Cámara Agraria Provincial 1987a,b,c).

Owners debated with public officials who supported the initial formulation of the basis for the new water legislation. Most of the arguments concentrated on 1) the constitutionality of the law; 2) specific policies; and 3) the economic, legal, and social consequences of expropriation and state water management.

The Unión de Heredades, Comunidades y Propietarios de Agua para Riego de Gran Canaria joined with the Cámaras Insulares de Aguas de Tenerife y de La Palma. In general, these groups felt that the law was an attempt to nationalize or socialize water. They argued that state ownership and control over water would be counterproductive because it would concentrate property rights rather than decentralize them and encourage inefficient production. The history of UNELCO, the Spanish energy company, demonstrated that state monopolies do not guarantee either efficient markets or resource allocation. Moreover, the state could never compensate owners or motivate members of water users associations to invest without secure private property rights. It is certainly true that the Spanish State monopolies under have not rationally allocated resources among competing economic sectors through the efficient operation of the markets (Tamames 1995). There has always been a great deal of public and private interference in the market. Critics were certainly correct that the value of the property held in private hands was far too great for the state to expropriate. Unfortunately, most of the critiques ignored the possibility that the transaction costs arising from the combination of decaying infrastructure and the corrupt market were partially responsible for forcing the costs of water so high that farmers and ayuntamientos could produce more water and lower market prices if they made state subsidized investments in desalination and water reclamation, reformed their water distribution system, and operated as public organizations.

Others attacked what they saw as an socialist inspired political policies which would undermining a 500 year old tradition of private property and local management that was appropriate to the insular environmental and economic conditions. However, as demonstrated earlier, the tradition they point too cannot be simply summarized as a private property regime. Property rights to water in the Canary Islands have never been monolithic or unassailable. It was far more complex than that. Individuals, families, non-kin based institutions, and the state stood in relation to each other as authorized users, claimants, proprietors, and owners. The state lost its initial hold over local waters, but had little incentive to interfere until it became the largest single purchaser of water in the archipelago, suffered tremendous deficits, and could only protect the health of the population and the state of the economy by making huge capital and administrative investments and gaining substantial control over the market. Furthermore, they were unable to explain why the existing property regimes should be protected from state encroachment as the island's infrastructural conditions took on aspects that resembled nothing like the Gran Canaria of the 19th century.

Editorialists also accused the government of free-riding. Again, my review of the history of water property regimes shows clearly that this was not the case. Without Madrid's financial support, the ayuntamientos had little ability to open and maintain their own mineshafts. They took the only option available to them. They exchanged their permission to destroy public springs for the right to acquire a portion of the water to supply drinking water to citizens who lost their own springs as a result of groundwater mining. If anything, most of the comunidades de aguas profited from these deals at the expense of the ayuntamientos and the farmers. Furthermore, once Madrid had access to capital, it quadrupled its investments in public hydraulic resources

Other criticisms suggested that the Canary Island water reforms were legislation and managerial plans that would inevitably lead to some sort of anti-economical bureaucratic dictatorship reminiscent of despotic agrarian states or industrial communist regimes (Ascanio 1986). In the same vein, Arquímedes Jiménez del Castillo (El Día 16-12-84), a lawyer and water owner from Tenerife, frequently accused the legislation's supporters of being naive communists and bad economists. Occasionally he took a more revealing tact.

> We do not wish to say that today's politicians are worse than those who came before. What happened was that during the Francist period there existed a break and healthy control over the whimsy of these directors, a control that does not exist now. This has given rise to the proliferation of the happy investor, and the effective creation of an operant fascism that lacks the least elemental economic criteria.[1]

This is a striking statement. He did not mention that Spain's fascist state held the greatest monopolies the archipelago had ever seen. Nor did he mention that public administrators lost regulatory control over its waters and did not pursue legal infractions because there was no cost competitive and alternative sources of fresh water. Jiménez del Castillo could accuse opponents of being communists, socialists, and economically naive fascists in the same breath. The common factor in these political ideologies is support for a strong centralized state apparatus that enjoys a relatively strong form of public property and administrative control to critical industries. I have to infer that Jiménez del Castillo considered any kind of strong, centralized state intervention as a danger and hated communism and socialism because they promised to redistribute wealth.

Why Didn't Water Owners Initiate Their Own Reforms?

Given the severity of the situation and their ideological emphasis on free enterprise, hard work, and social responsibility, one might reasonably ask why the water owners didn't undertake their own reforms before the state got involved? To answer the question, we first have to examine the value and distribution of the property in question. As I mentioned previously, the Association of Water Users of Gran Canaria found 30,675 shares of ownership rights to 594 water users associations. The 1,200 pozos and galerías on the island were worth 25.6 billion pesetas. The 6,100 km of pipes were worth another 19,550 million pesetas. The value of 3,030 water tanks approached 21.44 billion pesetas. The 62 large dams valued 11.5 billion pesetas. Together, private facilities were worth 78.04 billion pesetas Farmers invested another 48.6 billion pesetas in water technologies for their own farms. The total value of these private investments comes to 126.64 billion pesetas (1.2 billion dollars) That is larger than the combined investments made by farmers for all their agricultural equipment including walls, roads, ditches, storage houses etc.. It was estimated that all of the water facilities and private rights in the archipelago were equivalent to at least 3 years of the archipelago's annual budget.

The association's study also examined transfers in the water market. It estimated that only 17% of all of the water produced was sold in the market. The rest was used to irrigate the owner's own farms. The ayuntamientos purchased 75% of their water. The exact pattern of water consumption by activity changes spatially and economic activities. As I mentioned previously, the ayuntamientos of Arucas, Firgas, Valleseco, Teror and Moya bought almost all of their water on the market during the 1980's. That amounted to approximately 40% of the water produced in the region. Once you factor in sales to farmers, the percentage of water sold in the region probably climbs to about 70% of the total produced.

The farmers had every reason to protect their investments and have never advocated wasting water They had been crying out for reforms for years but did not initiate any Why? Two men who represented the water owners in negotiations with the government agreed that farmers and water owners could not afford to undertake reforms. They could not even raise the money to conduct the necessary research, let alone invest in new technologies. The Association of Water Users of Gran Canaria could conduct its study because water owners were trying to protect what they had, but it was another thing to try to solve their mutual problems.

Federico Aguilera Klink (1986), a professor of applied economics at the University of La Laguna, used neo-institutionalist economic theories regarding 'common pool resources' to explain why the owners never initiated the reforms. He argued that the market failed to promote efficient water management because the fluid nature of groundwater made it impossible to rigorously demarcate private property rights and to regulate access to the aquifer. Economic theory suggested that the only viable institutional reform was to create self-governing associations of public and private producers that treated island water as common property. The reason that none had yet emerged was that many water owners could still earn higher short run profits by competing than they could by uniting and managing water collectively.

Aguilera Klink and Rodríguez Brito (1989) co-authored an academic paper in which they argued that since groundwater had to be treated as a common property because it was a unitary resource drawn on by many competing actors. Under these circumstances, rational, self-interested resource users impose costs on each other by withdrawing a portion of the resource. The groundwater mining blitz in the 1940's created a dangerous situation in which the comunidades de aguas and heredades were over capitalized; there were too many capture points that could only be profitable by mining for all the aquifer was worth. Under the res nullis status of water in the aquifer and vague system of private ownership rights to water brought to the surface, it was in the best interest of each person to extract as much water as possible. The distribution of property rights and the profit brought by sales strengthened the hold over most of the water resources among those vendors and producers who could best profit by the destruction of most of the wells and charge ever higher prices to consumers. Furthermore, the rise of the inelastic tourist market made it possible for owners and vendors to mine passed the point of diminishing returns and even beyond the point at which they would destroy agriculture and ultimately the aquifer itself.

Aguliera Klink and Rodríguez Brito took the public institutions to task for their passive stance. Following work done by MacDonell and Howe (1986) and Young (1986), they argued that the water should be common property and regulated. The state would administer water rights and encourage producers to form consortiums, mancomunidades, and public comunidades de usarios. They argued that future water transfers had to conform to three conditions. First, the direct and indirect benefits accrued to the buyer and other individuals affected should be greater than the direct and indirect benefits to the vendor plus all of the normal transaction costs associated with the transfer of water. Second, the transaction costs should be cheaper than the alternative technologies. Third, the transfer should not place third parties at risk. In those cases where a water sale would leave somebody high and dry, the courts should do exactly what U.S. courts do — stop the trade.

I must reiterate that neither the fundamental legal and political issues nor the basic economic theories arose from Aguilera Klink and Rodríguez Brito's political affiliations. Common property theory, as it is derived from neo-classical and neo-institutional economics, does nothing to challenge capitalism itself. It neither recommends the destruction of all private property nor advocates Marxist-Leninism, Stalinism, or Maoism. All it says is that where more than one actor exploits a resource that cannot be divided into discrete physical units, the property regime most likely to inspire long term sustainable management is one in which the individuals form some sort of mutually recognized co-ownership or co-usufruct rights and coordinate their activities

Notice that there was really no reason arising from the common property theory itself that mandated public dominion over water. Successful common property regimes and collective administrative institutions can be found all over the world and may appear as either public common holdings if the institutions are viewed as corporate social groups or as a set of interlocking private rights if viewed from the perspective of the individual members. But, in no circumstances are these to be confused with dictatorial state managerial regimes.

For example, Californian water law, which has been repeatedly analyzed using common property theory, admits conjunctive ownership to water regardless of the public, common, or private status of any of the water users associations. As is consistent with my model, Rodríguez Brito and Aguilera Klink's advocacy of the declaration of public domain rested on two facts. First, the private sector simply could not raise the capital necessary to make the reforms alone. Second, public and private consumers were eager to take advantage of European and Spanish subsidies to invest in desalination and water reclamation technologies as long as they could also minimize their administrative and market costs.

Rodríguez Brito and Aguilera Klink's message was lost on most people who owned even small amounts of water. Rodríguez Brito has repeatedly accused the large scale vendors and water owners of manipulating the smaller owners. While he may be right, small-scale owners didn't need much convincing because they still relied on water sales for income. Hypothetically, a person from Arucas who sells ½ an azada (83 m^3) for a profit of 20 pts/m^3 can earn 1,666 pts/month or 19,920 pts/yr. That would cover a year's municipal water bill (14,580 pts/yr), assuming that the owner's family consumed the average 9 m^3/month (108 m^3/year) and paid 135 pts/m^3. People who owned as little as one hour of water (36 m^3) insist that every sale helps defray their own expenses and gives them or their grandchildren pocket money. They, at the very least, get a bottle of champagne from vendors at

Christmas. Manipulated or not, people with minimal rights to property felt they would loose the little bit they had managed to keep. Therefore, it was a simple task to *unfairly* depict them as doctrinaire communists and bad economists.

From Private to Public Domain

Initially, many leftists denied any desire to socialize, nationalize, or declare water part of the public domain. The credibility of such denials disappeared when Jerónimo Saavedra declared that the complex hydrological problems could be solved through stronger government control (CEDOC 1988: 27) in his Presidential inaugural in January, 1983. Saavedra's statement brought him into line with the Spanish Ministry of Public Works and Urbanism which was about to published a national bill that also declared public domain over all water but it placed him squarely against the old caciques who still controlled the water resources.

The political conflict intensified as committees prepared the National and Regional laws. Manuel Fraga, as President of the National Popular Alliance Party, offered his party's alternative to the National Bill. Water owners in the Canary Islands supported it because it supported the coexistence of public and private property rights. The state would make investments and hydraulic plans, but it would not create a centralized administrative bureaucracy and would let private individuals retain their ownership rights to water. The Spanish Congress rejected the Popular Alliance's bill.

In January of 1985, the socialist dominated government produced its own national legislation. The PSOE in the Canary Islands supported it partly because its 'Third Disposition' granted the Autonomous Canary Island Government authority to write its own water law and to govern under the existing body of national water laws until the new regional legislation was implemented.

The Canary Island water reform bill made it to the Canary Islands' parliament in 1987. It declared water to be a scarce natural resource and valuable economic good which the state had to manage and conserve for the common good. While the bill declared water and the hydraulic infrastructure to be part of the public domain, it allowed current owners to choose how they would proceed. Owners could acquire public proprietary concessions for as long as 15 years if they legalized their water works. If they declined, they would be governed under the existing legislation but not protected under the new legislation. The bill encouraged owners, heredades, comunidades de regantes etc.. to merge, form consortiums or mancomunidades, or become comunidades de usarios

The comunidades de usarios would be institutions whose members were to be what amounted to authorized users or claimants of publically owned waters and water facilities. They could acquire, use, and possibly manage public water facilities but could not exclude anybody else from gaining access to them. Only the Insular Water Council could do that. The comunidades de usarios were to be ruled under public law in a democratic fashion. The members were to have limited jural powers over themselves and would administer their own finances.

After examining the legislation, many of the ayuntamientos joined the water owners and business groups in opposition because it jeopardize their own weak water rights and would make them directly answerable to insular bureaucrats who could force them to make investments they felt would not be in their municipalities' best interests.

The Pacto de Progreso (Pact for Progress), the center-leftist coalition that dominated the Parliament, approved the bill despite the intense opposition. The Water Law of May 5th, 1987 took effect on July 1, 1987.

Public Reaction to the Water Law of 1987

The response to the law was swift. Comunidades de aguas stopped producing water and municipalities were left threatening to expropriate water. Some owners, fearing nationalization, sold their shares to others who enlarged their own holdings. The law's opponents sponsored public demonstrations in Santa Cruz de Tenerife on March, 27, 1987 ASAGA estimated that 15,000 to 20,000 people crammed into the Plaza de la Candelaria (Diario de Avisos 1987). Public agencies estimated that 10,000 to 12,000 turned out. Speakers demanded the resignation of Jerónimo Saavedra and José Manuel Hernández, the Commissioner of Agriculture. They insisted that the declaration of public domain might have been applicable in the mainland where most of the water resources had always been public But the legislation was ludicrous in the archipelago. The law would deprive people of their hard earned property, and thereby, one of the chief means by which they invested and saved money They wanted a law that would control groundwater mining, stimulate public and private investments, protect existing rights, and avoid creating expensive, inert bureaucracies

The bill's supporters insisted that it had never been the intention to deprive owners of their water or to destroy the water users associations. They only wanted to foment some sort of cooperative control over the water resources, eliminate speculation, protect the thousands of small farmers who were being driven out of agriculture, and ensure the tourist industry and public of an adequate water supply.

Jerónimo Saavedra tried to distance himself and the PSOE from the unpopular law He claimed that neither he nor the PSOE would have written the law as it emerged from the Pact for Progress, which he insisted was dominated by the Izquierda Canaria Unida (ICU) or United Canary Island Left. ASAGA reminded Saavedra that he and prominent PSOE spokesmen had defended the law until the last moment. Rodríguez Brito could not tolerate that strategic retreat and revealed that the law was a piece of compromise legislation. All of the negotiators conceded some points so they could identify common positions. The toughest negotiations concerned balancing competing social interests. The negotiations were not a clash of blind political ideologues searching for a communist utopia as many of the law's opponents continue to insist.

Voters took revenge at the polls in the following June elections. Political power moved towards the right center and as the AIC, CDS, and AP formed a new majority coalition. The new Parliament voted 31 to 27 to suspend the water law. Its President invited the PCE-PSOE to join with the AIC, CDS, and AP to suspend the law -- once it freed itself of its 'communist weight'. The PSOE, ICU and Mixed political parties voted against the measure.

Fifty five members of the AP filed a suit with the Constitutional Court. The suit questioned the relative autonomy of the archipelago itself. The Spanish Constitution considered the archipelago an historically autonomous community like Catalonia, the Basque Country, Galicia, Navarra, and Andalucia. The AP's suit claimed that, under the Constitution and the Ley Orgánica de Transferencias Complementarias a Canarias (LOTRACA), an organic law that transfers legislative and administrative powers, the autonomous community did not have the civil authority to regulate the nation's water. Therefore, the autonomous government could not claim regional supplies. The attack went much farther than challenging the authority over water rights, but effectively questioned the legitimacy of the autonomous government itself.

While the case went through legal procedures, the Canary Islanders formed their own opinions. Again, they were split by region and party affiliation. Forty eight percent thought that water should be public property. Another 30% felt that water should remain private property, but regulated by the government. Only 17% felt water should be private and unregulated. The opinions varied according to region. People in Las Palmas (Fuerteventura, Lanzarote, and Gran Canaria) were almost twice as likely to say that water should be public and regulated than people from Tenerife (Tenerife, La Palma, El Hierro, and La Gomera).

Public opinion largely conformed to political affiliations too. Most people who had recently voted for the AP defended private water rights while 25% thought that they should be public. Less than 5% of those who supported the nationalist coalition AC-INC and IU (United Left) felt that water should be private. While the independents wanted the government to regulate water issues, the leftists wanted public regulation of public property.

In general, the water law did not receive much public support. Forty five percent of those who supported the AP felt nothing good would come of it. AIC and CDS supporters held similar opinions. Socialists thought the law was useful. Most of the nationalists felt that the law brought some benefits, but less than 10% claimed it was good or very good. In the end, more than half of those interviewed felt the law should be modified. Twenty one percent disagreed.

The Water Law of 1990

The Constitutional Tribunal in Madrid broke the stalemate by upholding the water law and declaring that its suspension was unconstitutional. Despite the favorable rulings, the autonomous government could not implement the law without provoking a new round of protests. Instead, special interest groups and legislators produced the Water Law of 1990. The negotiators struggled with several key issues: property, technology; political representation in the insular councils, administration, price controls; hydrological plans; and subsidies.

Legislators could not afford to simply expropriate all of the private water sources, but they really didn't have. Most of the pozos and galerías were not profitable, the acequias and pipe lines were decaying, and storage tanks were not the major problem. Therefore, legislators agreed to extend the 15 year transition period to 75 years for those acquired concessions as authorized claimants and 50 years for those who chose to maintain their private ownership rights to water facilities that produced over 1,500 m^3 a year. Only those who acquired concessions would be permitted to revise their water works and profit from the sale of their water. All new water-users organizations would have to conform to public administrative laws. The older organizations would improve their chances of receiving financing if they modified their statutes and became public organizations too.

The property status of the distribution works like the sub-acequias or PMD's empire also had to be addressed. The PSOE and leftist groups demanded that the state prevent owners of distribution works and vendors from manipulating the market. The Water Law of 1990 declared water transportation to be a public service. Pipeline owners could charge cañones at prices set by the insular water council.

Another particularly sensitive point concerned the relative political control over the Insular Water Councils There were already two Direcciónes Generales de Aguas covering Las Palmas and Tenerife. Some argued that the water authorities should be controlled at the level of the autonomous government in order to avoid duplicating the bureaucracy and to avoid overburdening the insular governments. Negotiators decided that each insular council would include representatives from all levels of government and the various water related industries. Their water plans would be the active policy instruments.

Nobody was pleased. González Viétez (La Provincia 1990) declared that the people had been robbed by water owners and a government that blessed the status quo. Meanwhile, water owners begrudgingly accepted the law, not because they believed it would be effective, but because they suspected it wouldn't be. According to several representatives of the water owners, their constituents reasoned that they themselves would be dead, agriculture would be unprofitable, and the aquifer would be destroyed before the insular councils could act so they supported the law — in public.

Summary

I have argued that the conditions which created the European Community and transformed Spain's economy created some of the political conditions that made the power struggle between the old and new caciques possible. The transition from private groundwater mining controlled by a small cadre of owners, vendors, acequieros, and public administrators towards public ownership and mixed management over groundwater, oceanic, and waste waters has been complicated and contentious The conflict seemed like a battle between elites with opposing political ideologies. A better interpretation would be that the property regimes were shifting because private water owners and managers could not afford to make capital investments in the emerging technologies while their public and private clients had grown large and powerful enough to make their own publically subsidized investments. Thus, they could wrestle ownership and some measure of control away from the speculators and vendors. While the debates over the Water Laws of 1987 and 1990 may seem like clashes over communism and capitalism, the laws were not written by political ideologues. Their negotiators were highly skilled scholars, professionals, and public officials whose many interests were often in direct conflict. Ironically, their intense and balanced political confrontations forced them to draft and adopt a law that they doubted could work. In the next chapter, I will discuss how and why significant water management reforms are occurring despite their gloomy assessment.

Notes

1.

No queremos decir que los políticos de ahora son peores que los de antes, lo que ocurre es que durante el franquismo existía un férreo y sano control sobre las veleidades de estos directores, control inexistente actualmente. Ello ha dado lugar a la proliferación de la "alegria inversionista" y a la implantación de hecho de un facismo operario sin tener en cuenta ni el más elemental criterio económico.

CHAPTER 8
PROPERTY REGIMES IN THE NEW ERA

My general model says that changes in market opportunities and the techno-environmental relationships should change labor practices, demography, and water property regimes I have already demonstrated that significant market changes and technological innovations that have been occurring since the early 1970s. Furthermore, I showed that a prolonged conflict over water property and administrative law did take place. Were I to proceed from a model which grants theoretical priority to law and politics, the deep conflicts over the Water Law of 1990 would make it very tempting to predict that Gran Canaria's water industry would continue to languish. But according to my model, changes should occur

In this chapter, I will demonstrate that water property regimes throughout Gran Canaria are experiencing tremendous evolutionary changes despite continue legal resistence and institutional snares Just as has occurred throughout the history of Gran Canaria, the new property regimes are being selected for according to their ability to facilitate investments by those individuals and organizations which can most afford, defend, and profit from them under the current infrastructural conditions. Since many of these conditions are dynamic, there is no sound basis to predict whether or not the property regimes will solve the island's hydrological problems.

The Insularization of Water

Although the Canary Islands legislature has declared public domain, there is little reason to suspect that the water sources will be micro-managed by the Insular Water Council of Gran Canaria

The Council is a financially autonomous, legally recognized public entity The Council was supposed to have been in full operation by 1993 but began operating in 1995 It is absorbing much of the legal duties, political power, money, property, and staff from the Provincial Dirección de Aguas which will now assume research and technical duties. Many associated with the council feel that it's composition is a recipe for failure. They complain that the distribution of political power ensures close ties between politicians and water owners. This affiliation, some believe, will handicap administrative and disciplinary action. Engineers and administrators doubt the veracity of the few, irregular reports they receive from concession holders. Staff members complain that the specific institutional reforms were politically motivated and poorly handled. Negotiators ignored their input about how to improve the administrative processes.

Owners complain that the bureaucracy is too slow and that politicians neither understand the culture of water management nor have their best interests in mind. They complain about the costs of legalizing water work, providing periodic production reports, and applying for applications to extend mineshafts. Several water managers say they feel betrayed by the government because they were denied concessions to deepen their pozos after proving that significant water deposits could be mined. A few owners and workers candidly admit that they will extend their own mineshafts, illegally if necessary. Several already have.

The civil authorities admit that they cannot enforce legal changes if the producers and consumers do not have any way to adhere to them. A small force of water police and engineers regularly encounter illegal activities but do not initiate disciplinary measures. When they do, they risk provoking violence. For example, in the spring of 1994, farmers in Guayadeque prevented several members of the Guardia Civil from sealing off a disputed galeria that they relied on for irrigation and drinking water. Sensing the very real danger of being thrown off towering cliffs, the Guardia Civil wisely withdrew.

Even when illegal activities are made known to the council, the chances that any actions can be taken are minimal. The council has only one lawyer who works full time and will be lucky to get enough assistants to handle the work load. Furthermore, since the voting membership of the council is packed with individuals who may not benefit from the council's judicial decisions, cases brought to its attention may never be pursued. As one person in the water council asked me, "Do you really think that those who commit infractions will impose penalties?"

Ethnographic research and the history of water management on the island itself demonstrates that it is possible for people to monitor and control the members of water users associations under certain conditions which have yet to evolve in the new era. Reforms will only come if the European and Spanish administrations make the capital investments necessary to generate alternatives sources of water, build public water ways, and to grant private consumers proprietary or claimant rights so they can actively manage the water facilities.

The Insular Hydrological Plan

The Hydrological plan of Gran Canaria is supposed to help create the conditions under which water managers can eventually cooperate (Consejo Insular de Aguas de Gran Canaria 1995). Its goals are to increase the volume of water by shifting the bulk of production from groundwater to desalination and water reclamation. It seeks to realign the physical, property, and administrative connections between the surface catchments, mineshafts, desalination, water reclamation, storage, and transportation facilities (Figure 8-1). It contains 73 ministerial regulations and directives to reach its goals. Concession holders must install volumetric water meters and provide periodic information about their activities. The council will not grant new concessions in zones located above 800 meters. It will grant new concessions in other areas if the proposed works meet water quality standards and do not effect others within a radius of one mile. Municipal governments, industries, and tourist enterprises

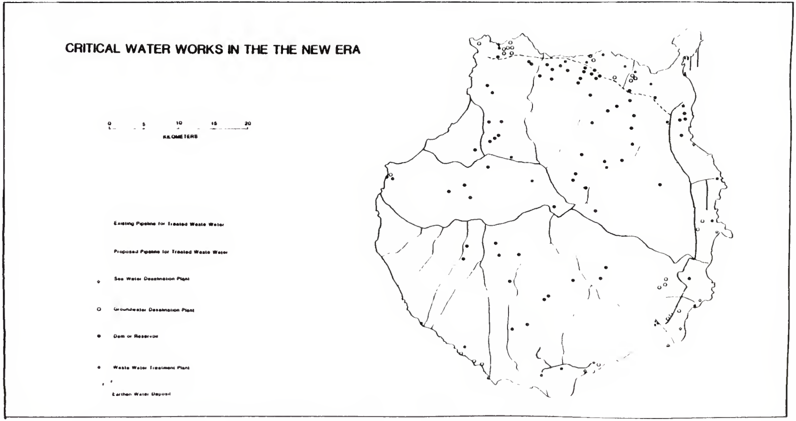

CRITICAL WATER WORKS IN THE THE NEW ERA
0
5
10
15
20
KILOMETERS
Existing Pipeline for Treated Waste Water
Proposed Pipeline for Treated Waste Water
See Water Desalination Plant
Groundwater Desalination Plant
Dam or Reservoir
Waste Water Treatment Plant
Earthen Water Deposit

Figure 8-1. Critical Water Works in the New Era

located lower than 300 meters in altitude must consume desalinated water. Those located above 300 meters have no viable choice but to consume groundwater. All of the municipal governments should reduce conveyance loses to 20% and either build or link their sewage lines with water reclamation facilities. Chemical dumping in septic tanks and in the sewage lines will be strictly regulated. Half of the water supplied to the urban consumers should be treated and sold to farmers.

The plan sets several targets for the years 1996, 2002, and 2012. It assumes that agricultural and industrial consumption will not vary while urban and tourist demands will increase. Water supplies will be distributed according to priority use. In order of priority, water will be allocated to supply domestic, agricultural, tourist, and industrial demands before water can be used to recharge the aquifer. Water production should increase from 131 Hm^3 to 150 Hm^3 in 2002 and 181 Hm^3 in 2012. The amount of groundwater produced should fall from 65 Hm^3 to 19 Hm^3. Since the amount of surface water available is determined by rainfall and retention facilities, there is little hope that these supplies will grow. The volume of desalinated water should jump from 38 Hm^3 to 72 Hm^3 in 2002, and again to 98 Hm^3 by 2012. Wastewater treatment and re-utilization should increase from 11 Hm^3 to 38 Hm^3 in 2002, and again to 52 Hm^3 by 2012.

Consumption rates should match supply increases. By 2002, the plan estimates that 71 Hm^3 will be consumed by agriculture, another 18 Hm^3 by tourism, and 59 Hm^3 for urban uses. Only 2 Hm^3 will be consumed by industry. By 2012, tourism should consume 23 Hm^3 while urban demand should rise to to 84 Hm^2. Any water that is not consumed will be used to recharge the aquifer. The planners do not foresee any consistent recharge rates until 2012.

The plan proposes some important changes in local production and consumption patterns for Valleseco, Teror, Firgas, and Arucas. It suggests that no groundwater should be used for agriculture by 2012. This target, like the assumption that agricultural demand will remain constant, is dubious. Unless there are significant changes in crops and the chemical quality of desalinated or treated wastewater improves markedly, coastal farmers will mix them with ground and surface water

From Groundwater to Desalination and Reclamation

The variety of ongoing reforms makes Gran Canaria seem like an encyclopedia of development case studies. Public and private consumers are taking advantage of subsidies, alternative water resources, and new technologies to reduce their own reliance on the exploitative water market and deteriorating aquifer. Comunidades de aguas and heredades which serve farmers are acquiring public concessions. The Insular Water Council estimates that it has granted about 400 concessions to comunidades de aguas, most of whom had to legalize covert operations. The council must still process about 800 more applications. Administrators from some of the comunidades de aguas and heredades say they transformed their private ownership rights to public concessions in order to have continue operating as proprietors of their current water sources — with the financial and legal assistance of the government. They also explain that those who are maintaining their private ownership rights tend to own mineshafts that are no longer profitable and are hoping that the government will expropriate them.

Many of the technical changes are drawing multi-national water management corporations into complex relationships between the state, private, and common water owners, proprietors, claimants, and authorized users. Farmer and ayuntamientos began to hire multinational and local water management corporations to operate, administer and maintain desalinators during the early 1980's. Just as is happening through out the world, the concession holders are setting production and quality targets and fixing profit margins. The companies must meet the criteria to make money. The farmers and ayuntamientos like the change because it is loosening the grip of vendors and they can operate on their own terms.

The effects are being seen in northern Gran Canaria. Water users groups that have already made the property and institutional reforms and made subsidized investments in desalination, water reclamation, and conveyance technology in Galdar, Guia, Santa Lucia, Ingenio, and Aguimes report sharp reductions in the market price of water and conflicts. Reforms in Arucas and Firgas are lagging behind those in Guia and Gáldar. The reason for this is simply that the topography around Guia and Gáldar is broader and flatter so farms tend to be larger, and thus capable of withstanding higher production costs. Banana plantations can absorb prices that bankrupt most of the farmers in Arucas, Firgas, Teror, and Valleseco.

Farmers in Gáldar and Guia formed several new comunidad de usarios and built their own desalinating plant next to the coastal municipal facility 5 years ago. Members claim that the desalinated reduced the average market price of water by 50% because it is sold at competitive prices, especially during summer droughts. Therefore, the profit margin taken by water owners and vendors has fallen to what local farmers and water owners themselves consider to be 'reasonable'. Water in Gáldar and Guía is still expensive, maybe too expensive to warrant increases in agricultural productivity, but at least the price will help give some small to mid-size farmers a fighting chance in today's highly competitive international marketplace.

Now that the water shortages in the north central region are driving market prices high enough to make desalination a reasonable alternative, more families, water-users associations, and ayuntamientos have made their own investments. At least 10 families in Arucas and Firgas have hired water management companies like Ionics or Tedagua and installed their own reverse osmosis desalinators and distribution systems since the mid-1980's. It makes simple economic sense; the market price of saline water, conveyance loss, profits, and the possibility of theft drove the average cost of water from 30 to 60 psts/m^3 to 120-180 psts/m^3. At that price, subsidized investments in desalination become more than just competitive, they can become cheaper.

Three desalinators have been operating in Barranco de Tenoya for 5 to 10 years. One family installed a desalinator in one of its coastal pozos after discovering an individual emptying a siphon they own and use to bring water from their pozo in Teror Another family has been desalinating and selling water to the ayuntamiento of Arucas. They pump over half of their saline water to Montaña Cardones where the ayuntamiento mixes it with water from Valleseco and then distributes it to residents The family also desalinates some of the remaining water before pumping it to Santidad where the ayuntamiento distributes it to residents there. The ayuntamiento, which had been as much as a year delinquent on its payments during the summer of 1995, recently used public monies to buy the pozo

The Comunidad Hoya del Cano, another privately owned institution, desalinates water from a pozos in Bañaderos. The pozo was constructed at the turn of the century when norias and malacates were being installed. Since then the pozo has been equipped with the fuel driven pumps. The owner worked with state agencies and received subsidies to replace his electrodialysis desalinator with a reverse osmosis desalinator in September and October of 1995. He uses the water to grow approximately 3 ha. of bananas.

The Comunidad del Polvorón uses electro-dialysis to desalinate water from a spring born at sea level just under the Barranco Quintanilla in San Andrés. Its water costs 87 pts/m^3 to produce and its saline content is low enough for banana irrigation.

The University of Las Palmas de Gran Canaria's school of agriculture is located just below Montaña Cardones. It holds shares in several heredades and comunidades and has just constructed its own desalinator. The school teaches students to construct farm irrigation networks, build greenhouses, conduct and interpret soil and water analysis, and to do the economic cost-benefit analysis needed to operate a farm these days. Furthermore, many students go on to learn about merchandising and marketing both in the archipelago and through out Western Europe. The agricultural business naturally draws people into international politics where they must fight for favorable tax laws, regulations, and subsidies. In addition to its pedagogical goals, the school also serves as an extension office that farmers rely on for soil and water analysis, advise, and saplings materials. Farmers travel from all over the island to submit their samples and to talk about how they can get better yields. The quality of the service is always a contentious matter, but the nominal price that the school charges simply cannot be beat.

The most important desalinator is still under construction. In September of 1995, Arucas joined Moya and inaugurated a desalinator in Bañaderos, Arucas. The Ministry of Public Works and Transportation provided about half of the financing and the central government matched municipal investments. The desalinator should be capable of producing about 5,000 m^3/day at a cost of about 100 pts/m^3. Since the desalinator will theoretically supply half the demand for Arucas and slightly more than half for Moya, it will free up at least 2,500 m^3/day (15 azadas). That will immediately reduce Arucas' dependence on 17 comunidades de aguas and make more good quality water available to farmers in Valleseco, Firgas, and Arucas. We will have to wait for the summer of 1997 to determine how much the desalinator will really affect market prices.

Changing Relationships Between the Lowland and Highland?

As I mentioned previously, highland consumers must continue to use groundwater because it is just too expensive to pump desalinated water above 300 meters in altitude. Therefore, the highland farmers and ayuntamientos are looking for ways to minimize their reliance on private sources. The depth of their need to change the property regimes was made very clear during the height of the 1995 drought when the demand for municipal water in Valleseco doubled because farmers could not get water from the vendors to irrigate their crops. The vendors had already contracted several months in advance to sell water to coastal farmers. The vendors also told highland farmers they would not be sold any water the following year if the drought continued. Locked out of the market, the farmers began irrigating with municipal tap water. The farmers were willing to spend 145 psts/m^3 for the municipal water because the drought forced the wholesale price of potatoes up to 200 pts/kg. The demand for the ayuntamiento's limited water supply grew so intense that Valleseco's Alcalde cajoled vendors into selling him more water. He even considered expropriating water from anyone who refused to cooperate. The situation put coastal farmers on notice that they would have to help solve the highland's water problems or face the possibility of having to turn to the market themselves after being forced to sell their own water to the ayuntamientos. Towards the end of the summer, water and farm owners in Arucas proposed an innovative idea to abate their increasingly adversarial conflicts with the ayuntamientos. They offered to exchange their property rights to highland sources with the highland ayuntamientos (Valleseco, Teror, Firgas, Tejeda, Moya and Artenara) if the latter would help them finance and build a large desalinating plant in Arucas.

There is another initiative to provide highland farmers with their own mineshafts. In October, 1995, a government official suggested that farmers in Valleseco seek government subsidies to buy several of the pozos and galerias. Fed up with a lifetime of unfulfilled promises, farmers are now pressing him to secure the subsidies. The effort comes at a good time, considering the willingness of lowland farmers to exchange their water rights.

Still, there is a chance that the highland farmers will not receive either government subsidies or mineshafts because the future of highland agriculture remains in doubt. Much of the cumbre and mediania have been designated as a natural park and the entire area is considered a recharge zone by the Insular Water Council. The park is supposed to promote ecological sustainability and tourism so farming and construction activities are intensely regulated. Residents are forbidden to cultivate some areas, and restricted in others. On the other hand, European funds earmarked to promote tourism are becoming available for residents who would be willing to convert their old farmhouses into overnight stops or bed and breakfast establishments. Public programs may even pay some farmers to continue cultivating their terraces to give tourists the illusion of a thriving rural economy. Nobody knows how these programs will be handled. One thing is certain, both the ayuntamientos and the farmers have been harmed for far too long for them to place much trust any program. The state will have to provide subsidies to help solve the problems that both the coastal and highland farmers and ayuntamientos face together.

Water Re-utilization

As indicated in Gran Canaria's hydrological plan, desalination is not, by itself, the key to solving the island's water problems. It will help provide potable water for the tourist colonies, cities and for some farmers, but it is not enough. The key to supplying the demand for irrigation water along the coast is supplementing ground and desalinated water with treated waste water. That means improving the performance of the existing treatment facilities and extending pipelines to comunidades de usarios to reuse the water. Several institutions designed to treat waste water and distribute it to farmers have been created. The Consorcio Insular de Aprovechamiento de Aguas Depuradas de Gran Canaria (Insular Consortium for the Use of Treated Water) was founded in 1992. It is engaged in the difficult task of renovating nine of the island's treatment facilities. Other organizations, such as the Mancomunidad del Surest and the Mancomunidad del Sur are also either operating successfully or have just been founded. Furthermore, a 60 kilometer long pipeline designed to carry treated wastewater from Las Palmas as far south as Juan Grande is now in operation (Canarias7, December 13, 1996). A pipeline designed to bring treated wastewater from Las Palmas to the farms along the northern coast is now in construction.

Consorcio Insular de Aprovechamiento de Aguas Depuradas de Gran Canaria

Much of the burden of supplying the island's farmers with treated wastewater falls to the Consorcio Insular de Aprovechamiento de Aguas Depuradas de Gran Canaria (Insular Consortium for the Use of Treated Water). Founded in 1992, its administrative body is composed of a General Committee, a Permanent Council, and a staff. The President of the Cabildo Insular is the President of the Consortium as well. The General Committee is composed of the President, Director of Operations, and representatives from the Ministries of Public Works, Agriculture, Environment, Political Territory. They are joined by the Alcaldes of the ayuntamientos and Counselor-Presidents from the Cabildo's own water and agricultural committees, a representative from EMALSA, as well as vocal representatives from Las Palmas, Telde, San Bartolomé de Tirajana. Lastly, there is a secretary-general and a treasurer. The voting structure of the enterprise is heavily weighted in favor of the Cabildo, the autonomous government, and Las Palmas. Together, their votes outweigh the other 20 members. The Consortium hired the CADAGUA company to repair and operate the 9 water treatment facilities under its control.

The effort to save small-scale agriculture depends on the Consortium's success. Unfortunately, the Consortium is in trouble. It has to make tremendous capital investments to treat, transport, and sell wastewater from different treatment facilities at competitive prices and quality to comunidades de usarios that are just forming. It is handicapped by its reliance on private and public organizations that do not share its objectives. Meanwhile, farmers who are aware of the conflicting interests within the Consorcio have begun clamoring to change their property status from authorized user to claimants so they can have more influence in how the consortium operates. Some suspect that the Consortium could become the island's biggest aguateniente and are considering forming an insular federation of comunidades de usarios to counterbalance the consortium's power.

The different circumstances confronting each of the nine treatment facilities cause the tenor of the relationships between comunidades de usarios and the consortium to ranges from cooperative to antagonistic. The Presidents of the comunidades de usarios in Tafira and Casablanca waged a public debate about the efficacy of the Consortium through the newspapers in 1995 after I returned to the US. From what I have been told, their opinions can be explained by the different physical circumstances, and economic interests in the areas.

The Comunidad de Regantes de Casablanca is a success story — so far. Its 26 members belong to the Sub-Acequia de Casablanca and cultivate grains, tubers, vegetables, and fruits in Buen Lugar and Casablanca, Firgas. Since Firgas relies on groundwater, its treated wastewater is usually good enough to use to irrigate salt intolerant crops like bananas if mixed with fresh water. The consortium helped the farmers build a pipeline from the treatment facility up and around a horseshoe valley to the sub-acequia Casablanca.

The consortium also provided the members with a model statute to help them organize and encouraged them to adapt it to their needs. By August of 1995, the comunidad de usarios established most of its rules. Its members decided that each had to pay an entrance fee plus cuotas based on the extent of their land holdings and type of crops they each cultivate. Each member receives one vote. All of the finances are public information but the names of the members are kept confidential. There is no dula, although farmers can not irrigate more than once every 20 days so all of the members may purchase treated water. The members purchase the water from the consortium by the cubic meter or in $36m^3/hr$ blocks. The comunidad charges an additional 2 pesetas to build a common fund.

Any member expecting water goes to the distribution point where the consortium's own pipeline meets the Sub-Acequia Casablanca. The area is located just in front of the President of the comunidad de usario's house, farm, and beverage distribution business. The farmer and President record the volumetric meter reading, open a valve, and let the water flow into the sub-acequia for the determined amount of time. At the end of the period they meet again, close the valve, and take a second reading. Nobody is paid for their labor.

The members are currently trying to solve several internal and external problems. The biggest internal problems concern the time frequency with which members may acquire water. Some members do not have storage tanks yet must irrigate every week but they are not supposed to purchase any water before the end of the 20 day cycle. The President currently stores water for farmers who do not have tanks, but agrees with members that this can only be an interim measure. Another problem concerns disciplinary powers. Since membership is public and voluntarily, some members do not want to give their political authorities any judicial or disciplinary powers. They have seen too many abuses of power in the heredades, comunidades de regantes, comunidades de aguas, and in the public institutions to have much faith in the ability of powerful people to dispense justice if they hold a stake in the decision. Their debate has not been resolved.

The comunidad is facing two external problems. The first is that the most powerful members of the Sub-acequia Casablanca are displeased by their use of the sub-acequia to transport what they consider to be tainted water. The members respond that the people objecting are vendors who do not want to loose their business. The members of the comunidad are taking precautionary legal steps to protect their rights. They control the tail end of the sub-acequia, pay their yearly dues, and are protected by statutes that permit treated or saline water to be transported when good quality water is not being transported. The second problem is that the consortium recently revised its prices from 42 to 74 pts/m^3, but has not improved its quality. Members agree that as long as treated water is good enough to mix and is cheaper than water on the market, they will purchase it and work together to solve their internal difficulties.

Farmers throughout the region are watching the Comunidad de Usarios de Casablanca. Many believe that the members are going to destroy their lands. Others, who have been using highly saline treated water for years, are considering forming their own comunidades in Cardones, Montaña Arucas, and Bañaderos.

In contrast, the members of the Comunidad de Usarios de la Sociedad Agrícola en Transformación (S.A.T.) are among the consortium's most vociferous critics. They hold authorized user rights to publically treated waste water produced in Las Palmas' treatment facility, Barranco Seco. The members have been using treated waste water for 20 years. They criticize the consortium for providing expensive, poor quality water on an irregular basis. Moreover, they accuse the consortium, and many of those associated with it, of profiting by not treating the water according to the chemical standards required for agriculture and selling it to a golf course in Bandama. They also complain that they occasionally have to do the consortium's administrative work because it cannot complete its own mission. They demand that the comunidades de usarios be admitted as members into the consortium so they can press the most powerful members (Las Palmas, Telde, the Cabildo Insular, Gobierno de Canarias etc.) to make the investments and organizational changes they need to get good quality water when they need it. In essence they are asking for rights as claimants.

The consortium is hindered by problems that it cannot readily solve by itself. The treatment facility called Barranco Seco II was constructed even though state officials knew that it would not work because the sewage in Las Palmas was far too saline to admit into the facility. The ayuntamiento of Las Palmas is facing several tough difficulties. Its world class desalinators are expensive to operate so its water is mixed with cheaper saline water to achieve the minimal chemical standards for potable water. Second, much of city's coastal areas are built on artificially created land masses that extend out onto the insular shelf. Many of its water pipes are old and have been fractured by the weight of buildings, automobiles, and soil so they take in sea water during high tides. Third, consumers increase the concentration of salts as they add detergents and human waste into the sewage system. Worse, industries which use large amounts of water as coolant pump saline water directly into the sewage lines. Thus, by the time the sewage arrives at pumping stations constructed to lift water from Las Palmas to Barranco Seco II, the salinity level is usually too high to admit into the plant so administrators have no choice but to dump it into the sea. That destroys the coast line, kills fish, and creates an incredible stench in front of the city's banking district.

Some skeptics wonder if the consortium was founded to achieve its goals. The consortium and the companies that operate the facility may legally break even or make a slight profit by not treating the water. The money they receive from the municipalities to treat the water is not contingent on their doing so. Therefore, they can cover their operating losses with the money. The companies themselves will have no real incentive to treat and sell water until Las Palmas repairs its own desalinators and produces, cracks down on industrial dumping, and lays down new sewage lines.

Government officials must offer the public tangible results in the short term. They intend to build a desalinator to reduce the load of salts in the treated water at Barranco Seco II. There are two looming problems with this proposal. First, the salts will damage the facility as they pass through. Second, the desalinator can only work if organic compounds that act as fertilizer are removed. That eliminates the mineral content that attracts farmers to treated water. Farmers in Las Palmas doubt that they would buy expensive water that lacks the nutrients they need to cut down on the cost of fertilizer. It may just be better to sell their lands to developers (which many businessmen and politicians would probably prefer).

As you can see, these problems confronting the consortium and farmers in Las Palmas are more difficult to solve than those confronting farmers along the northern coast. Therefore, farmers in Arucas and Firgas are more hopeful than those in Las Palmas, but they will not pin their hopes on treated waste water and are pushing for more desalinators.

The consortium has other informed critics too - its members. Their criticisms arise from their obligations to sustain the consortium even though they may not benefit by being able to use any of the treated water. All of the municipalities have to make substantial investments in new sewage systems and charge their citizens 25 pts/m^3 to treat water they will never use. Although they agree with the 'polluter pays' principle, they object to subsidizing elite agribusinesses while leaving small-scale farmers helpless. As one alcalde asked, "Who is going to buy expensive, hazardous water if they can't make a living with expensive high quality water?"

Several ayuntamientos found an alternative to the consortium. The farmers and ayuntamientos in Ingenio, Agüimes, and Santa Lucia withdrew from the consortium early on and formed the Mancomunidad del Sureste. The consortium has been trying to draw the Mancomunidad back into its fold, but has not succeeded. The mancomunidad desalinates and transports water to urban consumers. Then it treats and sells water to coastal tomato agribusinesses. Local officials and farmers view the consortium, CADAGUA, UNELCO, EMALSA, and Las Palmas with suspicion. They claim they withdrew to avoid some of the institutional problems crippling the comunidad de usarios in Las Palmas. The comunidades de usarios that operate with the Mancomunidad del Sureste enjoy authorized user or claimant status. They purchased rights to receive water, have open 24 hour access to the facilities, and participate as non-voting members in the management of the treatment facility. The mancomunidad will admit new claimants only if adding them does not reduce water quantity and quality for all of the other members. Since they cannot increase the water supply, they must reject many farmers who wish to join their organization.

The Mancomunidad del Sureste has been successful enough to attract the attention of the Comunidades de Usarios in Barranco Seco and Tafira as well as a delegation of Palestinian officials which is searching for institutional designs and property regimes that would help them solve water management problems in the Gaza Strip. The message coming from both directors and farmers in the Mancomunidad del Sureste is clear; a limited number of consumers can and must manage the resource, production, and distribution facilities with the help of independent, qualified water production companies and public administrations.

Other municipalities seem to be following the example set by the Mancomunidad del Sureste. San Bartolomé de Tirajana, Mogán and La Aldea de San Nicolás formed the Mancomunidad del Suroeste in July of 1996 to attend to common infrastructural and economic problems that would be extremely difficult to resolve individually (Canarias7, July 16, 1996). The mancomunidad is seeking Spanish and European Community financing to build water and solid waste treatment plants, improve local tourism and advertize abroad, promote agriculture, exploit groundwater, and to reforest the area. Their union is timely because Mogán's water supply is not potable and La Aldea needs to update its own urban systems. Plus, the waste water produced in the tourist centers of San Bartolomé de Tirajana could aid farmers who cannot acquire enough water from the Cabildo Insular's reservoirs.

Conveyance and Storage in the North Central Region

The farmers in Arucas and Firgas know that they cannot expect the consortium to solve all of their problems. They are seeking ways to produce desalinated water, reduce conveyance losses, control prices, and guarantee effective storage facilities. Once again, the changing sources of water are placing new pressures on the sub-acequias, and providing them with new opportunities. The Sub-Acequias Casablanca, Rosales, Alta, Vega, and San Juan-Cardones still have nominal leaders, even if they have not all been elected formally. Their aging, angry, and suspicious members must be convinced that the institutions can and should be reformed so they or their children can continue cultivating. The leaders, most of whom are relatively wealthy, must demonstrate they can all secure adequate supplies of water at acceptable prices and quality, reduce conveyance loses, eliminate water theft, and distribute costs equitably. Furthermore, they have prove that the investments would be recouped in a competitive wholesale market.

One way of convincing members to participate is to formalize and revise their statutes. The Comunidad de Regantes Sub-Acequia de Cardones formalized its customary rules in the early 1980's. The Comunidad de Regantes Sub-Acequia Alta is just completing its own statutes. The most revealing structural change deals with voting rights. Members are now allowed only one vote, whereas their voting rights used to depend on the amount of land they owned.

The sub-acequias have already begun to seek public support for their capital investments. Currently, the Sub-Acequias Alta and Cardones are charging canons for the passage of water in effort to amass enough capital to make start-up investments. The PRECAM 2000 (1995) outlines capital improvements for PMD, Heredad de Arucas y Firgas, Heredad de Azuaje, and the sub-acequias. The PRECAM 2000 project recommends that the acequias and cantoneras be replaced by pipeline and volumetric gauges. This change is already generating resistance because people throughout Valleseco, and to a far lesser extent, Firgas and Arucas, still wash clothes, water animals, and fill buckets of water at the acequias. The right to access and withdraw water from canals is still so important that the ayuntamiento in Firgas just built expensive staircases to lavaderos when it covered a portion of the Heredad de Arucas y Firgas's main acequia. Highlanders adamantly reject any suggestion of replacing the acequias with pipes. In their eyes, they would just be subsidizing the coastal rich — again..

Meanwhile, coastal farmers are reluctant to replace cantoneras with meters. They want to see their water flow through the cantoneras because that is how they measure volume. They fear that meters might create new ways to steal water and open them up to new external controls that vendors and the state could use against them. This too is an unresolved problem, but I don't think it will be a great obstacle because of several very important changes in the way water-users groups manage storage facilities.

Farmers in Gáldar and Guia recently created new comunidades de usarios to operate water tanks. The members pay entrance and yearly fees to *huecos* (unit spaces) so they can store a specific volume of water. The farmers measure the water entering the tank with volumetric meters and only pay for the amount they receive. Owners may take their water whenever they want. Some comunidades de usarios have installed individual pipes and release valves so every member to closely regulate their own water withdraws. Members of these comunidades are satisfied with the arrangements because they can keep precise track over their waters and have reduced the amount of conveyance losses.

The need to store and convey water is providing heredades and comunidades that operated tanks and dams with a new role. Recently, farmers have suggested that the Heredad de Arucas y

Firgas, and other organizations let members store water in their tanks and dams. Thus, the members of the Heredad de Arucas y Firgas would let people store ground, surface, and desalinated water in its reservoirs as long as it conformed to minimal quality standards. The members or farmers would direct the organizations to convey the water through the appropriate pipe or acequia. The statutes of the participating organizations would have to be revised; membership, distribution, voting, financing, and other rules would change. Again, all of these changes are still in the process of being debated.

Agriculture as an Alternative Life Style

Gran Canaria has changed so much over the past 40 years that the Autonomous Government of the Canary Islands, Spain, and the European Community are assisting efforts to revive agriculture. The Association of Young Farmers now touts agriculture as an alternative life style that may reduce urban blight, unemployment, poverty, drug abuse, and crime. Most of the farmers who attended the Association's chapter meetings in Arucas during the summer of 1995 were nearing the age of retirement; there were only a few young farmers. Those who attended the meetings discussed subjects ranging from alternative crops, chemical fertilizers and pesticides, harvesting, marketing, cooperatives, water treatment, and government subsidies. There won't be many more young people attending future meetings if some of these problems are not handled in the next few years.

Some farmers and municipal employees in Arucas are fighting the odds. A group of 40 middle-class families on Montaña Arucas have joined to put their terraces back into cultivation. They plan to utilize family labor and hire young people from Arucas for a few hours a day. The produce will be sold in local markets at competitive prices. The group has just acquired enough government aid to start their project after 10 years of planning and politicking. The members formed a comunidad de usarios and are now searching for water. Their success will depend to a large extent on the whether or not the other institutions succeed.

Summary

Desalination and Water treatment facilities have slowly been introduced to the island over the past 25 years. At this point, the costs of extracting groundwater under the private regime remains cheaper than the newer alternatives but the combined influence of conveyance losses, profit taking, tipping, and theft under the private regime make subsidized water production under a public regime a relatively cost effective option. Although phrased as a battle between political ideologies and powerful individuals, the real driving forces in the reforms have been the creation of urban coastal populations, technological innovations, the deteriorating condition of water, and the archipelago's incorporation into the European Community. The success of their efforts will depend primarily on the health of the tourist sector and the subsidies and protection that the archipelago's farmers and businessmen receive from Spain and the European Community.

CHAPTER 9

CONCLUSION

Anthropologists can offer relatively more compelling explanations for the evolution of property regimes than currently exist if we better operationalize our definition of property rights and shift our attention from the institutional characteristics of property owners to consider their social relationships with other kinds of propertied and non-propertied groups. We would also benefit by examining cases in which the intensification of agricultural and non-agricultural economic activities affect the evolutionary trajectories of property regimes. The changes in the mode of production will tend to encompass many of the more restricted topics like irrigation studies, the evolution of states, and the operation of water markets that anthropologists tend to study.

The Canary archipelago offers social researchers an excellent opportunity to untangle the factors affecting the evolution of water property regimes because the ecological and sociocultural characteristics of the islands vary tremendously. Furthermore, the existing hydrological and social research can help us document the transitions since the Spanish conquest 500 years ago

I offered a general model that I think helps explain the evolution of property regimes as Gran Canaria's dependent economy shifted the island's mode of production from hydro-agriculture to industrial agriculture to urban based services. My general theory stated that international market opportunities and the techno-environmental characteristics of the island such as climate, topography, and location of water resources lead those with the economic and political clout to make and defend capital investments. These investments directly affected the demand for labor, the population growth rate, and the settlement pattern The population and its economic activities determined the volume, timing, and spacial location of water demands. The initial water and land regimes were specifically designed to support the most lucrative economic activities. Since then, the property regimes have repeatedly adapted to external market and insular techno-environmental conditions despite legal and political efforts to preserve the status quo or to protect existing property regimes while supporting efforts to intensify the island's water production.

This model helps explain why the Spanish Crown granted colonists ownership to land and proprietorship to water. The Spanish state granted colonists ownership over land and proprietary usufruct rights over most water sources while granting everybody rights as authorized users to secure water for non-agricultural purposes. This way, the Crown directed much of the water resources to the production of sugarcane while ensuring that the entire population would have access to water for livestock and domestic purposes. It helped colonists formulate autonomous heredades and issued the Ordenanzas de Melgarejo to govern water management so that local water disputes would not immobilize the colonial judicial system.

The proprietary rights slowly became private ownership rights as the export market for sugar declined and subsistence farming reached into the highlands because the local property holders needed to exchange their deeds via inheritance, sales, loans, and sharecropping without the interference from a largely distant and uninterested state. During the process, highland farmers wrestled water from lowland farmers who could not guard their highland acequias. The Heredad de Tenoya lost most of its water because the lands in and around Teror could support a fairly large population and could not pay for guards to protect their water resources. The Heredad de Arucas y Firgas was far luckier because the Barrancos de la Virgen and Las Madres were far too steep to support a farming population It gained even tighter control over the areas water resources by making strategic purchases of land and water. However, the Heredad de Arucas y Firgas almost lost control over much of the waters flowing through Firgas because most of the farmers there had no rights to irrigate land. Furthermore, the heredad was unable to prevent the emergence of a coastal water market that helped farmers secure additional supplies of water during critical summer months. The water transfers begun through the market made it much easier for the water resources to become privatized and independent of land. All of these changes came about despite repeated judicial rulings supporting the status quo because the state had no way of enforcing its decisions. In a sense, the state could do little except to legitimize what had already occurred.

Meanwhile, the state itself reorganized in response to the collapse of the colonial empire and competition with stronger European states. The constitutional changes gave local inhabitants the opportunity to form ayuntamientos. The conflicts between the highlanders and lowlanders created new comunidades de regantes in Teror and Tenoya, but the organizations operated just like heredades which did not restrict irrigation practices as severely.

The comunidades de regantes that formed at the turn of the 20th century also operated in ways that conflict with the national water laws. In this case, the investors were not as much interested in irrigating distant parcels of land, but rather with selling water to farmers who would pay high prices to take advantage of European markets in potato, tomato, and banana.

The advent of mining and pumping technologies during the 20th century created an opportunity for farmers and speculators to form comunidades de aguas and mine groundwater. While many farmers invested in the comunidades de aguas to supply their own water needs, many investors were members of the professional class looking for good, get-rich-quick-investments. Although the national policy was to encourage increases in water production while protecting existing rights to water, the two property regimes were incompatible. In conformity with my general model, the investors who could raise the necessary capital to make and defend their investments quickly captured the bulk of the island's water. The change destroyed many of the smaller heredades and heredamientos, forced the ayuntamientos to make deals, and captured the business of farmers who didn't have enough to irrigate their lands. Rather than destroy the existing property regimes, the change in technology rendered them irrelevant

The distribution and market system that evolved in response to the topography and changes in water production not only united the valleys into a common distribution network. It also placed the ownership of the pipelines and the power to control the water markets in the hands of a few investors, vendors, and acequieros. Their manipulation of the market was adaptive in the sense that it provided individuals who could not purchase titles to water with an opportunity to secure enough to grow banana and other profitable crops Most people, however, do not emphasize the adaptive features of water theft and market extortion. They have nothing but bitter memories.

Once Spain began industrializing and creating a tourist industry in the archipelago, the returns on labor and water in agriculture dropped below that which wage earners could earn in the construction and service sectors. The entire structure of the labor force quickly shifted from agriculture to non-agricultural occupations that supported within a brief span of 40 years. Ironically, this not only forced ayuntamientos to become even more dependent on the vendors and bottling companies for water, it also created one of the preconditions necessary for the ayuntamientos and farmers to escape their grip. As the ayuntamientos grew, they eventually found it possible to take advantage of Spanish and European subsidies and the falling costs of desalination and water reclamation to invest in their own facilities. To some degree, farmers are doing the same thing.

The long debate over water legislation and property rights in the Canary Islands that occurred during the 1980's and early 1990's seemed more like a battle of caciques and political ideologies than a fundamental shift in technologies and the power relations between private producers and vendors and public/private consumers. But debates over capitalism and communism obscure the technical and proprietary issues facing water managers. The complex social relationships forming now cannot be simplistically described as unchecked capitalism, socialism, fascism, or communism. They, like many corporate relationships in today's rapidly globalizing market, are creating closer links between public and private agencies The profit motives remain, but corporations must now compete with each other and meet production and cost requirements established by their private and public clients

When examined against the backdrop of the entire archipelago, it becomes clear that the infrastructural conditions found on and among the islands selected for the evolution of a variety of property regimes that now seem to be on roughly convergent courses Lanzarote and Fuerteventura's arid climate and shallow aquifers forced people to rely on spring water and to capture rainwater Today they survive on water produced in public desalination plants operated by mixed corporations The comunidades de regantes that formed on La Palma (Batista 1995) and La Gomera (Aguilera 1992) are still viable partially because the smaller islands are more humid and never achieved the disastrous demand for water that caused farmers to drain Gran Canaria's and Tenerife's aquifers All of the islands are now in the position where they must begin to regulate groundwater mining and foster integrated resource management plans In order to do that they had to shift property rights away from private control to a form of property that resembles a hybrid of common and public regimes

In as much as significant technological and economic changes continue along the path they are on now, we can expect significant changes in property regimes to continue However, I want to make it absolutely clear that reforming property rights cannot ameliorate insular water problems by themselves because they are not the principal causes of change They are some of the important instruments of change. The success of water reforms on Gran Canaria is highly unpredictable because it depends to a large extent on dynamic external market forces in agriculture and tourism as well as subsidies whose future status are not guaranteed.

Several general predictions can be made about the property regimes we could expect to find in other ecologically complex archipelagos that exhibit signs of economic and political dependency and whose mode of production shifted their hydro-agrarian, industrial agricultural, and urban modes of production.

First, water rights in hydro-agrarian colonies will tend to privatize if water is scarce and must be allocated among individuals who have the capacity to connect their irrigation systems The colonists will treat water like a private good and transfer it without seeking permission from the state

Second, water users associations that operate in ecologically complex areas that foster the creation of highly fragmented farms will tend to form irrigation cycles that do not follow the classic up and down canal rotations famous in other areas. The basic reason is that each member will direct his or her water resources to crops on fields located in different ecological niches.

Third, as has been observed by Dahwan (1988), groundwater mining where few urban centers exist tends to create or strengthen private ownership of water resources and water markets. Again, water managers need to operate quickly and cannot wait for the state. If capital investments can be made collectively, then corporate groups such as the comunidades de aguas seen here can be expected to form. The exchange of water through the water markets may generate high transaction costs to the water owners if they do not own and manage the distribution systems.

Fourth, groundwater mining in areas where rights to springs already exist will most likely cause a fundamental change in the property regimes and control over water resources even if the state declares laws designed to protect those groups who obtain water from the springs.

Fifth, those regions experiencing rapid urban growth and whose principle public-supplies came form private groups will most likely find it difficult — and probably counterproductive to nationalize or expropriate the water supplies. Instead of becoming drawn into a ineffective debate over the advantages and disadvantages of communism and capitalism, civil organizations can encourage property transfers and control markets if they can make the capital investments necessary to create an alternative water supply to support their relatively inelastic consumer demands

Sixth, since most urban areas in dependent societies seldom have employees with the technical skills necessary to operate urban facilities, they may increase their water production and improve its quality by forming joint ventures with private corporations that are capable of managing the facilities.

Seventh, water management plans that pin their hopes on water re-utilization would increase their chances of forming strong cooperative bonds with water users groups if they are granted proprietary or claimant status to the water. Public re-utilization schemes that seek only to sell water to farmers may create unnecessary conflicts.

All of these propositions can be tested by examining other ecologically complex and semi-arid volcanic archipelagos that were colonized and have since shifted from agriculture to tourism. Some of the possible candidates for such a comparison include the Balearic Islands, Hawaiian Islands, Grecian Islands, Philippines, and islands in the South Pacific.

GLOSSARY

Abrevadores	Watering troughs located along the major canals.
Acciones	A note establishing partial ownership of property administered by a water association.
Acequia	A canal.
Acequiero	A worker who maintains and guides water through canals. They may also act as vendors.
Agua de Hilo	The portion of water that may be divided in 12 by natural gravity flow through a canal from its source.
Aguas Perdidas	Lost waters. Water which a property holder loses to seepage or poor management and could be transferred by the King to another person apart from any transfer of land.
Aguamagnate	Depreciative term for a water vendor.
Aguateniente	Depreciative term for a water vendor.
Albercón	Water deposit in which water volume is measured before it is distributed.
Alcalde de Agua	A public officials appointed by civil administrators and usually elected by members of heredades to act as an overseer with jural powers.
Aljibe	A subterranean water deposit.
Arrendatarios	People who rent land.
Aspersión	Spray irrigation.
Ayuntamiento	Government administration of Municipalities
Azada	A hoe with a short to medium sized handle and curvaceous triangular metal head.
Azada de Agua	A portion of water. The exact volumes vary among water users

	associations. Currently, the Heredad de Arucas y Firgas produces 24 azadas per day. Each used to contain 466 m^3 but, now contain 166 m^3.
Boca	The space between two stone blocks in a cantonera through which water flows.
Cabildo Insular	Government administration of the island
Caja de Agua	A small building housing a cantonera.
Cantonera	The architectural device used to distribute water.
Canon	A fee charged to those wishing to transport water through another individual's property.
Cata	A small diameter borehole.
Cochinilla	A tiny insect that lives on nopal cactus and produces an indelible red dye when crushed.
Comunidad de Agua	A private water users association whose members hold individual shares to portions of groundwater they own once it is brought to the surface and distributed to them during their turn in the dula.
Comunidad de Usario	A public water users association whose members enjoy rights as either authorized users, claimants, or proprietors of publically owned water or technology.
Comunidad de Bienes	A form of organization whose primary purpose is to generate profit for its members.
Comunidad de Regante	A public water users association whose members enjoy rights as proprietors to water and technology.
Consejo Insular de Aguas	An independent jural organization created by the Water Law of 1990 with powers to administer, plan, and police water management activities on an island.
Cumbre	The area located above 1000 meters and is normally utilized for forestry and herding.
Cuota	A yearly membership fee.
Depuradora	Waste water treatment facility
Derrama	A fee for water transportation over a given length of canal.

Desaladora	Desalinator
Desamortización	Spain's sale of property owned by nobility and the Catholic Church.
Dula	An irrigation cycle typically used in North Africa and the Mediterranean in which each property holder in a water users association may claim water during specific intervals of time or sequentially
Estanque de Barro	Earthen water deposit typically constructed by digging out soil until an impermeable layer is reached and then piling up rocks and covering them over with soil to for walls.
Fanegadas	A unit of measure common in the Canary Islands equaling 5,503 m2.
Fianzas	Money deposited in a bank by individuals with mining concessions that will be paid to indemnify anybody whose property or access to water had been damaged by their activities.
Galería	A horizontal infiltration gallery commonly called a qanat or adit in anthropological literature on water associations.
Gofio	Pulverized wheat and/or corn used as a staple food.
Goteo	Drip irrigation.
Gruesa	An undivided stream of water.
Heredad	A collection of individual property holders of public or private waters who have joined together to make common investments in water technology and administration.
Heredamiento	A collection of individuals who share water from a common source.
Huecos	Portions of space available in water deposits that may be rented or purchased to store one's own water.
Lavaderos	Areas along canals specifically constructed so residents could draw water and clean clothes.
Libradas	Shares to a portion of water produced by a water users association in exchange for the right to mine or transport water.
Madres	Large diversion walls that guide surface run off into deposits and canals
Mampostaria	Stone and mortar construction.
Mancomunidad	An association of public entities that cooperates to solve common

	problems.
Manta	Flood irrigation technique in which small areas around fruit trees are isolated and saturated.
Mar de Nubes	Sea of Clouds. The cloud formation that approaches the land between 600 to 900 meters.
Medianía	The land between 300-1000 meters in altitude that were characteristically cultivated by peasants and sharecroppers called medianieros.
Medianeros	Peasants and sharecroppers who cultivated land for absentee landowners provided they pay a variable percentage of their produce as rent.
Mayorazgo de Arucas	An old noble estate located at the base of Montaña Arucas that has since been sold to private individuals.
Nublina	The precipitation that falls when cloud formations pass over land. Also called Lluvia Horizontal or la Bruma.
Ordenanzas de Melgarejo	The codified norms governing property regimes to water and the conduct of Alcaldes de Aguas.
Panza de Burro	The solid grey mass of heavy clouds that hang over the coast of Gran Canaria during summer days.
Participaciones	A note establishing partial ownership of property administered by a water association..
Pilares	Water spigots constructed by public and private property owners to distribute water.
Pozo	A well mineshaft that is commonly 3 feet in diameter.
Pozo Negro	A sewage pit.
Pozero	A worker who constructs and maintains subterranean mineshafts.
Presa	Dam and reservoir
Propina	A tip which may or may not be obligatory to receive service from a vendor.
Ranchero	Water vendor.
Repartidores	Water distributors.

Repartimiento	The distribution of wealth in the form of resources and/or labor practiced by the Spanish Crown during its expansionary period.
Saltador	Employee who operates a water deposit tank and possibly a length of canal. They frequently sell water too.
Secuestro	The portion of water in water users associations that are sold to reduce the cost of production for each member.
Sobras	The remaining part of water that is not distributed through the established dula or consumed by the property holder.
Sondeo	A small diameter test borehole to search for groundwater
Sub-Acequia	A secondary canal that frequently forms its own water users association to maintain and operate the facility.
Suerte	A measure of land dimension which may equal approximately 6 fanegada and 38,663 m^2.
Surco	Irrigation technique in which water is guided between furrows.
Tabique	A mixture of cow and goat milk used during the famines in the 1930s and 1940's.
Tablilla	A small wooden block 80 mm high, 200 mm long, and 10 mm wide used to block off a portion of a cantonera's boca.
Tomadores	Parapets that serve to divert water into canals and deposits
Vista de Ojos	Method of estimating the rate of water production or volume by simply looking at it.
Vitola	A piece of wood with specific length used to determine the distance between the bottom of a tablilla and the bottom of a cantonera's boca.

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BIOGRAPHICAL SKETCH

Bryan Thomas Byrne was born and raised in Chicago, IL. He received a B.A. in anthropology at Beloit College in 1985 and a M.A. in anthropology with a certificate in ecological engineering from the University of Florida in 1990.

He has either studied or conducted field research in Peru, Colombia, Mexico, Spain, Belgium, Luxembourg, and the United States. He coauthored several articles on Brazilian color-race identity which were published in *Social Forces*, *Journal of Anthropological Research*, and by the Goeldi Museum. He published an article testing a cross-cultural theory about the sexual division of labor among craftspeople in nonindustrial societies in *Cross-Cultural Research*. He also wrote several review articles for the *Journal of Florida Anthropology* and *Cultural Anthropology Methods Journal*. He coauthored one paper on the evolution of Taino social organization in *ERES* and expects to see a related article on the social evolution of avunculocal chiefdoms and another article on Taino ceramic symbols published as articles and a chapter within the next year.

Bryan's work extends beyond academia. He spent three months during the fall of 1989 in Washington D.C. working for the Institute of Policy Studies on an internship project for the United Nations Center on Transnational Corporations. The purpose of the project was to describe and identify the causes and consequences of the contributions made to global warming by Western multi-national corporations. He also worked as a consultant for Fulbright to evaluate its Seminar on the European Community in 1995. Bryan just completed a summary of the main socioeconomic factors affecting American households and revised two series of educational pamphlets on personal finance for the County Extension Office of the University of Florida. One series is directed for low income individuals with remedial reading skills who need to learn to make a budget. The other pamphlet targets middle income families who must utilize our complex financial institutions to protect their possessions and health while saving for future expenses like child rearing, education, housing, and retirement.

This dissertation is the result of Bryan's longstanding fascination with the social consequences of resource management. He is trying to develop better cross-cultural theories to account for the evolution of property regimes and will soon return to the Canary Islands to continue his ethnographic research. Bryan is seeking employment opportunities that will permit him to travel the world to conduct basic and applied research on water management, demography, ecological economics, corporate culture, and property law.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Marvin Harris, Chair
Graduate Research Professor of
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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Anthropology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1996

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